६०४३४१

REPORTS

OF THE

DIRECTOR

OF THE

MICHIGAN MINING SCHOOL

FOR

1890 1892

LANSING, MICH.:
DARIUS D. THORP, PRINTER AND BINDER,
1893.

TABLE OF CONTENTS.

1890-1891.

I.

§ 1. Appointments of Instructors.
§ 2. Number of students, 1890-1891; (*a*). By States and Countries, (*b*). Average age.
§ 3. Number of students, 1891-1892; (*a*). Average age.
§ 4. Students from Lower Peninsula; (*a*). From other States.
§ 5. Occupation of fathers.
§ 6. Students from colleges and other schools.
§ 7. Admission of graduates of high schools, without examination.
§ 8. Employments of graduates.
§ 9. Number of students, by State or Country; (*a*). By birthplace, (*b*). Birthplace of father; (*c*). Occupation of father.
§ 10. Number of students entering from each school; (*a*). College graduates; (*b*). Undergraduates.
§ 11. Graduates, 1888.
§ 12. Graduates, 1890.
§ 13. Graduating class, 1891.
§ 14. Lengthening of school year.
§ 15. Desirability of a four years' course.
§ 16. Admission fees.
§ 17. Average cost of instruction; (*a*). Comparison with that of other institutions.

II.

§ I. Labors, duties and needs of the Instructors in the different departments. (*a*). Library; (*b*). Geological and Mineralogical Departments; (*c*). Recitation rooms. (*d*). Removal of boilers; (*e*). Storage of fuel; (*f*). Donations; (*g*). Dormitories; (*h*). Gymnasium, etc.

III.

§ 1. Instruction in the different departments. (a). Mineralogy: Lithological collection
§ 2. Relations of students to Faculty.

IV

TABLE OF MINING ENGINEERING STUDENTS IN LEADING SCHOOLS.

V.

REPORT OF THE DEPARTMENTS OF MATHEMATICS AND OF PHYSICS

§ 1 Summary of work and of students
§ 2 Text-books.
§ 3. Methods of instruction
§ 4. Objects of the courses
§ 5 Progress
§ 6 Needs
§ 7. Preparation of entering students
§ 8. Extra lectures.
§ 9 Changes in the courses.
§ 10 Required preparatory studies

VI

REPORT OF THE DEPARTMENT OF CHEMISTRY

§ 1 General chemistry.
§ 2. Qualitative analysis
§ 3. Quantitative analysis.
§ 4. Equipment and needs

VII.

REPORT OF THE DEPARTMENTS OF ORE DRESSING, METALLURGY, ASSAYING AND METALLURGICAL ANALYSIS

§ 1 Ore dressing.
§ 2. Metallurgy: (a) Of iron, fuel and refractory materials; (b) of copper; (c) of steel; (d) of lead, gold and silver; (e) of iron steel, fuel and refractory materials; (f) of copper.
§ 3. Assaying.
§ 4. Metallurgical analysis

VIII

REPORT OF THE DEPARTMENT OF MECHANICAL AND ELECTRICAL ENGINEERING.

§ 1. Drawing: (a). Blue printing.
§ 2. Mechanical Engineering; (a). Properties of Materials; (b) Mechanism; (c) Shop Practice; (d). The Steam Engine; (e). Engineering Appliances; (f) Mechanics of Materials (g) Testing of Materials.
§ 3. Rearrangement of work shops.
§ 4. Equipment.
§ 5. Donations.
§ 6. Needs.
§ 7. Electrical Engineering.
§ 8. Heating Apparatus.

IX

REPORT OF THE DEPARTMENT OF MINING.

§ 1. Mining and Mine Surveying; (a). Subjects; (b). Method of Instruction; (c). Practical work at the mines.
§ 2. Plane Surveying.
§ 3. Topographical Drawing.
§ 4. Hydraulics.

X.

STRATIGRAPHICAL GEOLOGY AND PALEONTOLOGY.

XI

PETROGRAPHY.

XII

REPORT OF THE LIBRARIAN.

§ 1. Extent of library; (a). Use by students; (b). Card catalogue; (c). Needs.

REPORT.

To the Honorable, the Board of Control of the Michigan Mining School:

GENTLEMEN:—The Director of the Michigan Mining School has the honor to submit to you the following report for the year ending November 30, 1891.

I.

§ 1. During the past year the following changes in the officers of the school, or in their positions have been made. Mr. Lucius L. Hubbard was appointed assistant in mineralogy, and Mr. H. B. Patton was appointed instructor in mineralogy and petrography, each to serve from September 16th; Mr. John F. Rowland instructor in mechanical engineering and drawing, to serve from September 1st. The title of Professor Keller's department was changed from that of chemistry and assaying to that of chemistry, and Mr. F. F. Sharpless was transferred from the position of instructor in chemistry and metallurgy to that of instructor in ore dressing, assaying and metallurgy; Mr. Fred W. Denton from mining and engineering to mining engineering and surveying. Mr. Walter J. Baldwin, who served as assistant in mineralogy during part of last year, was appointed instructor in mathematics and physics, commencing September 16th. However, before Mr. Baldwin could enter upon his work he received, upon the recommendation of the director of this school, the appointment of professor of mining engineering in the University of Illinois. The position offered him by the University of Illinois was much better than anything that the Michigan Mining School had at present to give him, and it was accepted by Mr. Baldwin. Mr. Baldwin had proved himself to be an efficient teacher, and deserved his promotion.

§ 2. During the school year ending September 11, 1891, there were enrolled sixty-five students in this institution, classified as follows:

SUMMARY.

Graduate students	5
Class of 1891	9
Class of 1892	8
Class of 1893	43
	65

(a) *By States and Countries*

Canada			1
Colorado			1
England			1
Illinois			4
Massachusetts			1
Michigan	Upper Peninsula	33	48
	Lower Peninsula	15	
New York			1
Pennsylvania			1
Utah			1
Wisconsin			6
			65

(b) *Average Age of Students:*

First year	21 years
Second year	24 "
Third year	23 "
Graduate students	30 "
Average age of all the students	24½ "

§ 3. The school year of 1891-92 commenced on September

14th, and has now continued for two and a half months, with an enrollment of sixty-eight students, divided as follows:

Graduate students	1
Class of 1892	8
Class of 1893	15
Class of 1894	44
	68

This is a much larger attendance than we had last year at this time, and there is every prospect that the attendance will increase to some extent during the remaining portion of the year.

§ 3. The average age of our students continues high, as shown in the following list:

First year	21
Second year	22
Third year	24
Graduate students	33
Average age of all the students	22

§ 4. One very gratifying feature in connection with the increase of students is the increase in the number from the Lower Peninsula of Michigan, as the following list, giving the number from that part of the State that attended each year, will show:

1886-87	2
1887-88	6
1888-89	8
1889-90	7
1890-91	15
1891-92	21

This indicates that the work of the school is beginning to be appreciated in that part of the State, and affords an education which answers the question, "What shall we do with our sons to afford them an occupation for their future life?" answers it for part of the citizens of the entire State, and not for the residents in the Upper Peninsula of Michigan alone.

(*a*). In examining the list showing the residence of the students, one can observe, as was shown in the report for last year, that the greater portion come from the State of Michigan: but there are representatives from twelve other States and countries, showing that the general course of the Institution has met with approval, not only in its own State, but elsewhere. The largest number of students from any State except Michigan are, as heretofore, from Wisconsin, which has five. In considering the birthplace of the parents, as was done in our last report, on page twenty-two, it will be seen that the larger number are of foreign birth,—of whom ten were born in England, and ten in Germany. Of the United States, the State which furnished the largest number is New York, twelve. Michigan is the next in order with nine. Of the students that are attending the school the list shows that forty-six of the sixty-eight were born in the State of Michigan. This much may be said in reply to those that object to *the State's educating young men* that are *residents of other* States, that, as a rule, those men remain in this State and assist in the development of its industries, while those who are born and educated in this State are more apt to leave it and to work in other regions. This will be seen to be borne out to a certain extent by a list of our graduates and their occupations, which will be given below.

§ 5. It is thought that the table of the occupation of the fathers, given on page twenty-three of our last report, could be profitably given again for the present sixty-eight students in attendence on this school. While, out of the total number of students (111) that had attended up to the time of the presentation of the last year's report, there were forty-seven different classes of occupations on the part of the father, this year out of sixty-eight students thirty-seven different classes of occupations are reported, including those of deceased fathers. The farmers lead in number, as before, the merchants standing next in order with those whose parents are deceased. It will also be noticed in examining the list that very many grades of work are represented, and that, while some of our students are in good financial circumstances, the great majority of them belong to classes that have to make their way in the world, and in very many cases these students have to have assistance in order to complete their education here.

§ 6. The ratio of college students that have entered this school has increased from 7½ per cent to 10½ per cent, while out of the sixty-eight present members of the school, thirty-one, or nearly one-half, have entered from colleges, or from schools of equal grade. A table is appended showing the different institutions from which the present students have entered during the past year. It can be compared, if desired, with the list given on pages seventeen and eighteen in the last annual report. Of these students the largest number have entered from the Lake Linden High School, which has sent ten, or double the number that have come from any other one institution. The Michigan Agricultural College and Hancock High School have each sent five, the Wisconsin State University three, Hillsdale College, Houghton High School and Illinois State University two each, and the other schools are represented by but one each. This gives us a representative from forty-six different institutions in different parts of the United States. It is very gratifying to be able to report that the grade of preparation of students that apply for entrance to the Mining School has been greatly improved during the past year, and every effort seems to be made on the part of the schools that are fitting pupils for this institution to endeavor to do work of the grade and character required; in fact the efforts of the high schools and other institutions in this state in that direction are very greatly appreciated.

§ 7. The arrangements for admission of the graduates of the high schools into the Michigan Mining School have proved, on the whole, very satisfactory, and lead to as thorough preparation and as thorough work as if they were accepted upon examination here. It is a well known fact that in new surroundings and with strange examiners the best men often fail and the poorest ones succeed in passing. By the method we have adopted, a very few weeks' attendance upon the school tells the faculty whether any mistakes have been made in admission; and as students are upon probation they can be easily and readily dropped, or required to make up their deficiencies. Again, from the method we have adopted, every principal and superintendent is placed upon his honor in recommending students to us. If he fails in this, the remedy is in our hands, never to receive students from him again. Thus far I can say that there does not appear to be any evidence that we have been deceived intentionally by but one superintendent or principal since the Mining School has been organized. On the whole, it would seem that the present plan works satisfactorily, and that there is, for the present, no need for change. Attention may be especially called to the work of the Lake Linden High School, which, in the number of students sent us, stands first, and in the character and grade of the preparation of its students stands second to none.

§ 8. As will be seen by the list of our graduates, appended to this report, the demand for good men has been greater than the supply; and all who are not employed owe that fact entirely to their refusal to take places, or owe it to various personal reasons rather than to the want of opportunity, since the director has not been able to supply the calls made upon him for graduates properly prepared for positions that were open.

§ 9. NUMBER OF STUDENTS FROM EACH STATE OR COUNTRY.

California	1
Canada	1
Colorado	2

England		1
Illinois		1
Indiana		1
Michigan	Upper Peninsula 30 Lower Peninsula 21	51
Montana		1
New York		1
Ohio		1
Pennsylvania		1
Utah		1
Wisconsin		5
Total		68

(a). *Number of Students Born in each State or Country.*

Canada	4
England	2
Illinois	4
Indiana	1
Michigan	46
Minnesota	2
New York	1
Ohio	2
Pennsylvania	1
Utah	1
Wisconsin	1
Total	68

(b). *Birthplace of Father.*

Canada	7	
England	10	
Germany	10	
Ireland	5	
Scotland	4	
		36
United States		
Indiana	1	
Maine	1	
Massachusetts	1	
Michigan	9	
New York	12	
Ohio	1	

United States—		
Pennsylvania	4	
Vermont	2	
Wisconsin	1	
		32
Total		68

(c). *Occupation of Father:*

Banker	2
Book-keeper	1
Butcher	1
Carpenter	3
Cashier	1
Clergyman	1
Clerk	1
Commercial agent	1
Copper refiner	2
Deceased	5
Doctor	1
Druggist	1
Editor	1
Engineer, stationary	2
Engineer, Mechanical	1
Farmer	6
Insurance agent	1
Justice of the peace	1
Lawyer	2
Lumberman	4
Machinist	2
Manufacturer	1
Merchant	5
Mine superintendent	3
Mine surface laborer	1
Mining	4
Postmaster	1
Probate judge	1
Retired	4
Secretary	1
Shoemaker	1
Steel manufacturer	1

Superintendent railway mail service	1
Towing	1
Traveling salesman	1
Undertaker	1
Vessel owner	1
Total	68

Thirty-seven different classes.

10. NUMBER OF STUDENTS ENTERING FROM EACH SCHOOL.

Adrian (Mich.) High School	1
Alma (Mich.) College	1
Battle Creek (Mich.) High School	1
Bay City (Mich.) High School	1
Bessemer (Mich.) High School	1
Calumet (Mich.) High School	1
Casnovia (Mich.) High School	1
Champion (Mich.) High School	1
Chicago (Ill.) High School	1
Chicago (Ill.) Manual Training School	1
Cleveland (Ohio) High School	1
College of Montana	1
Colorado State University	1
Detroit (Mich.) Business University	1
Detroit (Mich.) Jesuit College	1
De Veaux (N. Y.) College	1
Durham College of Science (Newcastle, England)	1
Farmington (Mich.) Graded School	1
Flint (Mich.) High School	1
Franklin and Marshall College (Pa.)	1
Green Bay (Wis.) High School	1
Hancock (Mich.) High School	5
Hanover (Ind.) College	1
Hillsdale (Mich.) College	2
Houghton (Mich.) High School	2
Illinois State University	2
Ishpeming (Mich.) High School	1
Ionia (Mich.) High School	1
Ionia (Mich.) Poucher Business College	1
Lake Linden (Mich.) High School	10

Marietta (Ohio) College	1
Michigan Agricultural College	5
Michigan Military Academy	1
Michigan State University	1
Milwaukee (Wis.) High School	1
Mount Hermon (Mass.) Academy	1
Northern Indiana Normal School	1
Notre Dame (Ind.) University	1
Pasadena (Cal.) Academy	1
Port Huron (Mich.) High School	1
Ripon (Wis.) College	1
Rockland (Mich.) High School	1
Salt Lake City (Utah) Collegiate Institute	1
Tennessee State University	1
Toronto (Can.) University	1
United States Naval Academy	1
Wisconsin State University	3
Total	68

a	Number of college graduates	7
	Ratio to whole number of students	10⅓ per cent.
b	Number of students entering Mining School from Colleges or schools of equal grade	31
	Ratio to whole number of students	45 per cent

THE GRADUATES, 1888.

Name, Residence, Occupation.

HARRIS, JOHN LUTHER, S. B. ... Quincy, Mich.
Assistant Mining Engineer, Quincy Mine.

LONGYEAR, EDMUND JOSEPH, S. B. ... Mesaba, Minn.
Explorer.

PARNALL, SAMUEL ALEXANDER, S. B. ... Ishpeming, Mich.
Chief Mining Engineer, Cleveland and Iron Cliffs Mining Co.

PARNALL, WILLIAM EDWARD, S. B. ... Cornell University.
Electrical Engineering.

REID, WILLIAM JOSEPH, S. B. ... Ishpeming, Mich.

SEAGER, JAMES BENJAMIN, S. B. ... Hancock, Mich.
Mining Engineer and Chemist, Tyler's Forks Mine and Lake Superior Redstone Company.

UREN, WILLIAM JOHN, S. B. ... Hancock, Mich.
Civil Engineer, Mineral Range and Hancock & Calumet Railroads, and County Surveyor, Houghton County.

GRADUATES, 1889.

CROZE, WALTER WILFRED JOS., S. B. .... Negaunee, Mich.
Chief Engineer, Jackson Iron Company.

FARWELL, PAUL, S. B. .... Musquiz, Coahuila, Mexico.
Assayer.

***FESING, HERMAN WILLIAM, S. B.** .... Crystal Falls, Mich.
Mining Engineer and Chemist.

***HAAS, JACOB, S. B.** .... Ishpeming, Mich.
Assistant Mining Engineer, Cleveland and Iron Cliffs Mining Company.

HOATSON, JOHN, S. B. .... Butte City.
Assistant Mining Engineer and Assayer, Butte and Boston Company.

PRYOR, REGINALD CHAPPLE, S. B. .... Houghton, Mich.
Mining and Civil Engineer.

§ 12. GRADUATES, 1890.

DANIELL, JOSHUA, S. B. .... Opechee, Mich.
Assistant Mining Engineer, Tamarack, Osceola and Kearsarge Mines.

DRAKE, FRANK, S. B. . Negaunee, Mich.
Chief Mining Engineer, Schlesinger Mining Company.

FESING, HERMAN WM., S. B., E. M. Crystal Falls, Mich.
Mining Engineer and Chemist.

HAAS, JACOB, S. B., E. M. Ishpeming, Mich.
Assistant Mining Engineer, Cleveland and Iron Cliffs Mining Company.

HODGSON, WILLIAM ADAMS, S. B. Houghton, Mich.

SUTTON, LINTON BEACH, S. B. Palmer, Mich.
Mining Engineer and Chemist, Volunteer Mine.

WAKEFIELD, ARTHUR ALBERT, S. B. Milwaukee, Wis.
Mining Engineer.

§ 13. GRADUATING CLASS, 1891.

BOSSERT, OTTO HENRY . Houghton, Mich.
Student, Michigan Mining School.

CLOSE, FRED BAGLEY Hancock, Mich.
Civil and Mining Engineer.

DENGLER, THEODORE . Houghton, Mich.
Student, Michigan Mining School.

DYER, HOLMES HAYWARD Ishpeming, Mich.
Assistant Mining Engineer, Cleveland and Iron Cliffs Mining Company.

FINK, EDWARD .... Houghton, Mich.
Student, Michigan Mining School.

---

* See Graduates of 1890 for the Second Degree.

Lawton, Nathan Oliver......................Ironwood, Mich.
Chief Mining Engineer, Colby, Aurora, Palms, Superior and Comet Mines.

McDonald, William Neal....................Ishpeming, Mich.
Assistant Mining Engineer, Cleveland and Iron Cliffs Mining Company.

Palmer, Edward Vose.......... ....Negaunee, Mich.
Assistant Mining Engineer, Schlesinger Mining Company.

§ 14. One of the most important changes has been the lengthening of the school year by one term during the summer, which is devoted to practical work in field surveying, shop practice and geology. The work of the summer term is thrown open to all parties that are properly prepared to do that work, in order to assist those that are not able to attend the regular work at other times. It is hoped that in this way a certain amount of good may be done.

§ 15. One thing is forcing itself very strongly upon the minds of the faculty, upon the students and upon the patrons of the school; that is, that the work of the institution is too severe and too weighty to be accomplished in the present three years course. There is, perhaps, no school in the country that requires constant attendance for seven hours per day in the schoolroom as this one does, demanding that the preparation for the day's work be made entirely outside of those seven hours. This places a very heavy burden upon young men, in the preparation of their work, particularly in mathematical subjects, if they do it as they should. It is, therefore, desired that at the earliest moment practicable our course should be changed to four years, thereby enabling the work to be distributed over a greater extent of time for all the subjects taught. This matter was discussed in the last report, on pages 39-40, to which your attention is invited.

§ 16. A growing feeling has been observed in the State of Michigan that all of the State schools should charge admission from students outside of the State. This feeling is probably not an unjust or unwise one, and the director of the Michigan Mining School sees no objections to charging a tuition, the equivalent of that of other schools in the country, as soon as the Legislature of the State shall have provided the means for the proper and full equipment of this institution to do the work that it should do.

The act organizing this institution limits the charge upon students of the State to $30. The highest tuition charged by any institution in the United States is $200. If the extreme limits here mentioned were charged all students, it will be seen that the income afforded the institution in this way would amount to only $4930.00.

In nearly all institutions the cost to the institution of the education given to its pupils is very much *greater than that* which the latter pay for their tuition, even *in the case of* those from whom the largest tuition fee is *obtained. This is* particularly the case in technical education, which is far more expensive than literary education, as *it requires more* buildings, laboratories, and appliances of every sort. These certainly must be provided unless the State wishes to give an education in technical work that shall not be worth the giving.

§ 17. In examining the report of the treasurer of the Michigan Mining School as given last year on page 136, it was found that the average cost per student to this institution was $427.61. This expense was found later in the year to be lowered to about $350 per student. With the increase of students we can naturally expect that the expenses to the State will be materially lessened, but they can never be placed as low as those in a school in which the majority of the students are taking literary studies.

(*a*) In order to ascertain, as nearly as possible, the expense of educating students in other institutions in which work of the same grade has been followed, we find that the per capita cost at the Case School of Applied Sciences is about $450.00. At the Colorado State School of Mines it is $300. At Cornell University the engineering students are estimated to cost the institution $500 each, or three times as much as the estimated cost of the students that are not pursuing technical studies. A list is appended showing the number of students each year at Harvard University from 1875-91 with a per capita cost of the students for each year. This shows that the cost varies from about $370.00 to nearly $500.00, averaging $428.42. It is to be remembered that this estimate includes not only the technical students, but all the literary students as well.

I think it will be seen from the figures given you, that considering the grade and character of education that is now being given in this institution, the per capita expense is low, and that there cannot certainly be charged against the administration any extravagance.

ESTIMATED COST TO THE INSTITUTION FOR EACH STUDENT PER YEAR.

Case School of Applied Sciences	$450 00
Colorado State School of Mines	300 00
Cornell University	500 00

HARVARD UNIVERSITY.

Year	No. Students	Total Expense	Per Capita
1875-76	1,278	$479,011 19	$375 52
1876-77	1,370	507,763 91	370 63
1877-78	1,344	524,983 27	390 61
1878-79	1,332	509,016 80	382 14
1879-80	1,356	588,225 71	433 80
1880-81	1,364	582,300 73	426 97
1881-82	1,382	622,536 83	450 46
1882-83	1,428	779,705 70	546 01
1883-84	1,522	767,894 26	504 53
1884-85	1,586	649,374 88	409 44
1885-86	1,662	626,900 86	377 20
1886-87	1,688	699,425 40	414 35
1887-88	1,812	725,716 40	400 50
1888-89	1,899	812,539 30	427 87
1889-90	2,079	1,028,651 65	494 78
1890-91 Treasurer's estimate			450 00
Average per capita from 1875 to 1891			428 42

II.

§ 1. The attention of the Board of Control is especially called to the reports of the instructors in the different departments in this institution, which are appended to this report. In those reports you will find a statement of the instructors' various labors, duties, and needs, and to all of these I invite you to give careful attention. In the Chemical Department there is a strong need for better means for electrolytic work, which is rapidly becoming an important part in technical analysis.

A beginning has been made upon the Metallurgical Laboratory, but it will only enable instruction to be given the students in the treatment of free milling ores. For smelting purposes a number of furnaces and a larger appropriation are needed. The Metallurgical Department was discussed quite fully on pages 61–67, 109–110, and to this you are respectfully referred, in order to avoid the necessity of repetition of the same ideas. Many additions have been made in the Physical Laboratory, in the Chemical Department, and to the Mining and Mechanical Engineering Departments. All these additions have been made in the line of advance, and for the sake of better work and better teaching of the students.

(*a*). Additions have been made to the library to quite an extent during the past year, but very much more still remains to be done, since the library is one that is used by every instructor, and should be used by every student. All persons that are familiar with the demands of modern education will admit that a library commensurate with the needs of the different departments in the school is an absolute necessity, if good work is to be done. In fact, during the past year, very much that the director has attempted to do for the institution has been stopped, or done under very great disadvantages and at a great loss of time, for the want of a much fuller and better library than the school now possesses. The needs are greatest in books of reference and in complete sets of the important technical periodicals. These evils have been remedied to some extent, but still much more remains to be done. Unless one wishes to spend his entire time in doing the things that have been already done in mining engineering, metallurgy, geology, and chemistry, or in any other subject, he must have at hands the means of ascertaining what others have done in those directions, and this can only be done by the possession of a good library; otherwise the time of the instructors of the school will be taken up, of necessity, in doing a large amount of work that is of no real benefit to the institution.

True economy of time demands a good library as much as a good laboratory for each subject.

(*b*). In the Geological Department collections are especially needed in Economic Geology to illustrate the phenomena of veins, the mode of occurrence of ore deposits, and to show the crude materials of the earth that are valuable for man's use, in order that the student may be familiar with and know them when he shall meet them in his subsequent work.

In Crystallography there are needed more of the crystal models and of mineral crystals to illustrate the commoner forms of crystals, in order to give the student more drill than we can give at present, in the practice of determining the forms of minerals.

This need is urgent and important, in order to enable the mineralogical work to be done as it should be. A collection of specimens illustrating the general structure of rocks and their mode of occurrence, together with models and a large number of maps and photographs, is wanted. These are particularly needed, because during a large portion of the year, especially during the time that the instruction is being given, the students are confined to the laboratory or lecture room, and unless the principles in which they are instructed are thoroughly illustrated, the work is not of the proper grade and not properly and thoroughly understood, since it is impossible to convey, in words, a full and accurate idea of natural phenomena, and of the mode of the occurrence of ores or of other minerals of economic value.

(*c*). An important need of the institution is larger recitation rooms, since the classes have increased to that size that many of them can not be accommodated in the rooms designed for them. At the present time the class in mathematics has to be transferred from the mathematical recitation room to the mining engineering room: and there are at present in the school building but two rooms large enough to accommodate classes the size of the present first year class.

(*d*). This evil can be easily overcome if the needed additions to the school buildings can be obtained, with the erection of a Metallurgical Laboratory. There should also be removed from the main building of the Mining School all the boilers, in order to reduce the danger from fire or from explosions, which is now a constant menace against the safety of the material collected here. With the removal of the boilers the Mechanical or Electrical Engineering Departments should also go, as economy of work requires that the Mechanical Laboratory should be in immediate juxtaposition with the power furnished for running the shops. This would relieve two of the rooms on the second floor, and with the removal of the Assay Department, which is to be provided for in the Metallurgical Laboratory, three large and three small rooms in the basement would be vacated which could be readily fitted up for recitation purposes.

(*e*). One special need in connection with this institution is some place where fuel can be stored. The present system of obtaining the fuel in small quantities, from day to day, as the size of our store room will allow, is a wasteful and expensive system, especially as the fuel comes to us (and of necessity must come under this system) covered with a greater or less amount of snow during the greater portion of the time. It cannot be urged too strongly, that the furnaces be removed from the main school building, and that there should be a place for the proper storage of at least a year's fuel on the grounds of the school itself.

(*f*). During the present year, Mr. J. M. Longyear has continued the fund to which reference was made on page 50 of the last report. An additional gift has been made to the School by Mr. A. Lanfear Norrie, of $5,000, to increase the Dormitory Fund established by himself.

(*g*). One very strong need of the school, which will have to be supplied through private benevolence, is for better and more economical accommodations for the home life both of the pupils and of the faculty. At the present time, there are not in the town of Houghton anything like the accommodations there should be, for an institution of this size, to take care either of the students or of the teachers.

(*h*). There is also great need for a special building to be established by private benevolence as a general reading room, gymnasium, lecture hall, etc., so as to provide for exercise and entertainment of the students during such spare time as they may have. The social side of a student's life requires as much, if not more, care than the educational side, or the mere question of his room and board. This is a matter of the greatest importance to be attended to if we wish to keep the students well and healthful, both physically and morally. The attractions for evil are always open and always ready to entice the student. Our students are gathered from different localities, many of them hundreds, and some of them thousands of miles from home, and unless some effort is made to look after the social side, weariness, home-sickness, and a natural craving for relaxation ensue. If the means for proper relaxation were provided, as there always should be, no harm would result, but very much good. When proper relaxation is not provided, the tendency is to seek relaxation of some kind in an evil way, since that is all that is then open or can be found by the student. What can be done to aid the pupil in his physical and moral needs is an all important and pressing question.

III.

§ 1. *All the members of the Faculty appear to have given* their attention very thoroughly to their work during the past year. and I have only to speak in commendation of their efforts.

Special credit is due to Professor Haynes for time taken outside of his department in caring for the records of the school as secretary of the Faculty. This is a laborious work and one that requires painstaking care. which he certainly seems to have given faithfully and well.

Mr. Kidwell has also devoted a great deal of labor and extra time in endeavoring to correct defects in the construction of the boilers. in putting in an efficient electric bell system. and in various other labors of that kind. which are outside of his proper duties. His skill and faithfulness in this direction are certainly deserving of high praise.

So far as the general school work, or the character and work of the different departments are concerned, it would be invidious to specify the work of any one of the instructors. since all appear to have worked hard and faithfully to do whatever the needs of their departments have called upon them to do.

(*a.*) During the last year the Director with his assistants gave instruction in mineralogy to thirty-eight students. During the present year instruction has been given to two classes in this subject. one numbering thirty-five and the other twenty students. In addition to this the lithological collection has been arranged. labeled and put in order for use in a series of lectures which are now being given to members of the graduating class. In the division of this work the lectures have been given by the Director, and the laboratory work attended to by his assistants.

§ 2. On the whole. the relations of the students and the Faculty have been of a very pleasant character: although last year it was necessary to cause the removal from the institution of a number of young men whose work and general character were not of a grade to commend themselves to the Faculty, or to redound to the credit of the institution if they were allowed to remain. The result of this disciplinary action has proved to be very beneficial, and has led to a marked improvement in the character of the work and in the general behavior of the students.

Below is given a table showing the number of Mining Engineering students in the principal schools of Mining Engineering in the United States during 1890-91.

This table gives as accurately as could be ascertained from the catalogues, or otherwise, the numbers enrolled in each course, including special students as well as those who are candidates for a degree.

Several schools that have just established a course in Mining Engineering are omitted, as there are no data available here concerning them, except that, in general, they have few or no students of Mining Engineering.

It will be seen that the list but slightly changes the relative position of each school, in numbers, from that given on pages 25-27 in the last report.

IV.

NUMBER OF MINING ENGINEERING STUDENTS IN THE LEADING SCHOOLS OF MINING ENGINEERING FOR THE YEAR 1890-91.

Michigan Mining School, Houghton, Michigan	65
Lehigh University, South Bethlehem, Pa	52
School of Mines, Columbia College, New York City	42
University of California, Berkeley, Cal.	30
Massachusetts Institute of Technology, Boston, Mass	22
Ohio State University, Columbus, Ohio	19
College of Montana, Deer Lodge, Montana	17
Lafayette College, Easton, Pa	16
Washington University, St. Louis, Mo.	15

Missouri School of Mines, Rolla, Missouri	12
University of Michigan, Ann Arbor, Michigan	6
University of Pennsylvania, Philadelphia, Pa	6
University of Illinois, Urbana, Illinois	5
Colorado School of Mines, Golden, Colorado	4
Dakota School of Mines, Rapid City, S. D.	2
University of Wisconsin, Madison, Wis.	1
University of Minnesota, Minneapolis, Minnesota	0

Very respectfully,

[Signed,] M. E. WADSWORTH.

HOUGHTON, MICH. December 15, 1891.

ANNUAL REPORT OF THE DEPARTMENTS OF MATHEMATICS AND OF PHYSICS.

Houghton, Mich., November, 1891.

DR. MARSHMAN EDWARD WADSWORTH,

Director of the Michigan Mining School.

DEAR SIR- In accordance with the laws of the State, I have the honor of transmitting to you my annual report of the Departments of Mathematics and of Physics, in the Michigan Mining School. This report covers the period extending from December 1, 1890, to November 30, 1891, and will therefore include the time of a previous report, extending up to March 1, 1891, and published in your report to the Board of Control for 1886-1891. For this reason I have referred to that report in some degree, in the preparation of this.

The following table shows the number of classes taught, beginning with the fall term of 1890 and ending with the present term, with the names of the studies, the number of weeks and the number of hours per week each class has been taught, together with the number of students in each class.

§ 1. FALL TERM, 1890

Subjects.	No. of Weeks.	No. Hours per Week.	No. in Class.
Analytic Geometry	14	5	9
Higher Algebra	8	5	26
Higher Physics	14	5	29
Trigonometry (Plane: right triangles)	6	5	27
Winter Term, 1891.			
Differential and Integral Calculus	14	5	7
Analytic Geometry	9	2	22
Analytic Geometry	5	5	22
Higher Physics	14	3	23
Trigonometry (Plane: oblique triangles)	7	5	27
Trigonometry (Spherical triangles)	7	3	23
Spring Term, 1891			
Analytic Geometry	6	5	16
Laboratory Physics	6	15	14
Fall Term, 1891			
Differential and Integral Calculus	14	5	16
Higher Physics	14	3	29
Trigonometry (Plane: right triangles)	14	2	30
Higher Algebra	14	5	32

§ 2. TEXT BOOKS USED IN 1890-91.

Names:	Authors
University Algebra	Olney.
Trigonometry	Wentworth.
Analytical Geometry	Wentworth.
Elements of Physics	Ganot (Atkinson's)
Practical Calculus	Peck.

TEXT BOOKS FOR 1891-92.

University Algebra	Olney.
Trigonometry	Wentworth.
Analytical Geometry	Wentworth.
College Philosophy (Physics)	Olmsted (Sheldon's).
Practical Calculus	Peck.
Analytical Mechanics	Peck.

§ 3. METHODS OF INSTRUCTION.

The methods of instruction used include the recitation, the lecture, the solution of practical problems, and laboratory work.

The recitation is found indispensable, as a means of giving the student a clear comprehension of the principles and rules involved, while it encourages exactness in the use of terms and in the statement of these principles and rules; moreover, in the earlier part of the course, especially, it is a powerful aid in holding the student to regular, systematic study, and thus becomes a potent auxiliary in the formation of a habit of incalculable value.

The solution of practical problems by the student is found of great value in familiarizing him with fundamental principles and their use. The lecture is employed in giving the student a wider grasp of the subjects under discussion than the recitation affords; while the laboratory work required of the student, not only fixes firmly in his mind valuable knowledge acquired in recitation and lecture, but it, at the same time, makes it thoroughly practical, and also encourages logical thinking, careful manipulation and original investigation.

No student is permitted to take this laboratory course who has not taken, in a satisfactory manner, all the required physics preceding it.

In this laboratory work, each student is required to perform his experiments independently, so far as is possible; to record neatly his data, with illustrative drawings, loci, computations and conclusions, in a note book, *during laboratory hours each day*, and to return his book to the instructor at the close of each day's work for his inspection and criticism. *No subsequent changes are permitted to be made in these notes.* This method encourages more carefulness and accuracy on the part of the student, and also makes him more self-reliant.

While the studies of mathematics and of physics are especially valuable as a means of mental discipline, yet the amount of such discipline does not depend as much on the character of any branch studied as upon the *method* and the *spirit* in which the student does his work. No student can expect to succeed without faithful, persevering effort. In fact, the best genius God ever gave a man consists in worthy purposes and hard work.

Besides the text books in daily use, the student is required, frequently, to consult the more extended works of reference found in the library of the school, in order that he may not only acquire a more comprehensive view of the topics under discussion, but that he may learn how to properly use such works—one of the necessary requirements of a thorough, practical education.

In laboratory physics such works as Everett's "Units and Physical Constants," Stewart and Gee's "Elementary Practical Physics," Pickering's "Physical Manipulation," and Kohlrausch's "Physical Measurements" are in constant use in the laboratory, for reference.

14. OBJECTS OF THE COURSES

The principal objects of the courses in mathematics and in physics, are: first, to see that the student obtains a sufficient theoretical knowledge of the branches required,—the fundamental truth being kept constantly in mind that the best preparation for practical work is based upon a thorough theoretical foundation: and second, to prepare the student with a thorough *working knowledge* of the subjects studied, in order that he may be able not only to make the necessary applications of this knowledge, required in the other, subsequent, and more practical courses of the school, but that he may be better able to apply it in his profession.

The splendid and forceful illustrations of the great value of the practical applications of the sciences of mathematics and of physics, exhibited by the extensive mining operations in the immediate vicinity of the school, I have found to be very helpful in encouraging the students in their study.

§ 5. PROGRESS.

Since taking charge of these departments in September, 1890, about $500 have been expended in the purchase of additional apparatus for lecture purposes in physics, and about $1,200 in the purchase of apparatus for the use of students in the physical laboratory. About $100 have also been expended in necessary fixtures in the laboratory.

I have the pleasure of reporting that this apparatus was received in time for use in the spring term of 1891, and that fourteen young men took this practical laboratory course during that term, with much satisfaction to myself and, I believe, with much of benefit and encouragement to them. Their work was mostly in the domain of physical measurements, and consisted of the theory and use of such instruments as the spherometer, the micrometer, the barometer, the common balance, the Jolly balance, Pierce's bridge, the Wheatstone bridge, the thermometer, the sliding-coil magnet; the astatic-needle galvanometer, the mirror galvanometer, the tangent galvanometer, the Delezenne circle, the sonometer, the calorimeter, the specific gravity bottle, the hydrometer, the vernier, the photometer, the sextant, lenses, etc.

Some valuable improvements have been planned for this course, and it is hoped that they may be introduced during the coming spring term.

§ 6. NEEDS OF THESE DEPARTMENTS

In my report to you in March last, I estimated that the mathematical department needed an immediate expenditure of $150 for a slated globe for use in teaching spherical trigonometry, and for solids for illustration in teaching the higher mathematics; in the same report I estimated that there would be needed, in the next two years, at least $4,000 for the physical laboratory, $3,000 for additional permanent equipment, and $1,000 for current expenses.

In reviewing this matter, I find my estimates certainly low enough, in view of the fact that the class in this laboratory will be larger by about fifty per cent next spring than it was last spring. And yet, because the Legislature so largely cut down the appropriations asked for and needed, it will be necessary to curtail the work in some degree, and patiently wait for a more just and liberal appropriation.

The entering class is so large the present term that there is not room for it in the mathematical room, and so the class is temporarily provided for by having it meet in the recitation room of the mining engineer.

Some provision will be necessary, in the near future, for an enlarged recitation room for the classes of these departments.

Only one other solution of the difficulty occurs to me, and that is, to grade these large classes, putting the more able and better prepared students in one division and the rest in another. This would certainly be to the mutual advantage of both divisions in such large classes in mathematics and physics, but this plan would require an assistant in these departments a part of the year. I am fully convinced, however, that the latter solution is the better, and would be for the best interests of the school.

17. PREPARATION OF ENTERING STUDENTS.

In my former report, to which I have already alluded, I had occasion to speak of the fact that some of the entering students from the high-schools had not taken some of the required preparatory studies, and others had not been sufficiently thorough in those which they had taken.

I there predicted that this state of affairs would speedily pass away, when the superintendents of these schools became better acquainted with the requirements for entrance to this school.

I am pleased to report that the entering class this year show a marked improvement in the thoroughness and extent of their preparation, and, because of this, are doing much very commendable work. I desire here to again emphasize the necessity of thoroughness in the required *preparatory* mathematics and physics. The subject of factoring in algebra, and that of solid geometry should receive *especial* attention.

§ 8. EXTRA LECTURES.

During the present term, I have given several extra lectures on the calculus and in algebra, outside of school hours. They had to be given at a very inconvenient time, as the students are kept very busy with their regular work. I have been much gratified at the large attendance upon these discussions, and the interest manifested in them; in consideration of the unfavorable conditions under which they have been given, and the added fact that attendance upon them is voluntary.

§ 9. CHANGES IN THE COURSES.

Beginning with the present term, the time of the study of higher algebra has been changed from five hours a week for eight weeks to five hours a week for fourteen weeks, while that part of the course in physics covering the first two terms has been changed from five hours a week to three hours a week for the twenty-eight weeks, the extra two hours a week being devoted to recitations in mathematics.

From present indications, I judge that these changes will prove an advantage.

Respectfully submitted,

ARTHUR EDWIN HAYNES.

§ 10. I append the list of the required preparatory studies for entrance to these departments:

Arithmetic (including the metric system), plane, solid and spherical geometry, algebra (including quadratic equations), and elementary physics.

I would recommend the use of such text books as the following, in preparing for entrance to these departments:

Arithmetic: Wentworth's (high school), Olney's Practical and Robinson's Practical. Geometry: Davies' Legendre (revision of Van Amringe), Wentworth's (new), Olney's (latest edition), and Chauvenet's (revision of Byerly).

Algebra: Wentworth's (school), Robinson's Elementary, Loomis's Elements, Olney's Complete, and Van Velzer and Slichter's (school).

Physics: Avery's Elements, Gage's Elements, and Appleton's (school).

A. E. H.

VI.

Houghton, Mich., November 14, 1891.

Dr. M. E. Wadsworth,
Director Michigan Mining School.

Dear Sir:—Herewith I have the honor of submitting to you the Annual Report of the Department of Chemistry, extending from December 1, 1890, to November 30, 1891.

Yours, very respectfully,
HARRY F. KELLER

REPORT OF THE DEPARTMENT OF CHEMISTRY.

An outline of the plan upon which the instruction of this department was conducted last year is to be found in my last annual report, and such changes and modifications of it as a year's experience with the students of the school has shown advisable were mostly embodied in the description of the course published in the new catalogue.

§ 1. GENERAL CHEMISTRY.

The total number of students in this subject at the begining of the winter term was twenty-eight. The lectures and recitations were attended by twenty-three, while twenty-seven worked in the laboratory.

Four hours a week were devoted to class-room work, in which the recitations from Richter's Inorganic Chemistry were continued, and lectures illustrated with experiments given when necessary. The subject of the non-metallic elements was finished, and the study of the metals commenced.

Two of the students left the school during the term, and several others, unable to keep up with the studies, were advised to take the work again the following year. In consequence only fourteen students remained in the class.

An examination was held at the end of the term and the subject continued and completed during the spring term.

To the laboratory exercises four hours a week were devoted in the winter term; the experiments in Smith and Keller's "Laboratory Notes" were continued and finished by the majority of the students.

While the results obtained were on the whole satisfactory, they showed that the lectures should be confined to the discussion and experimental demonstration of the fundamental principles, and greater prominence be given to the recitations. The two main difficulties with which I had to contend were lack of assistance and the inadequacy of the lecture equipment, which latter was pointed out in my last annual report. Both have been partially removed. Being relieved of part of his janitorial work, Mr. Gibbs has been able to assist this term in the laboratory instruction of the beginners as well as in preparing the lecture experiments. A considerable portion of this year's appropriation was expended to procure apparatus for illustrating the lectures; numerous additions, however, are still required.

The number of students enrolled in general chemistry for the present term is thirty-six. All but two of them perform the practical exercises, and thirty-three attend the class-room.

Of the seven hours, weekly, available for the subject, three are devoted to lectures and recitations, while the other four are spent in the laboratory. The text-book is the same as that used last year, Richter's, the laboratory manual is Smith and Keller's "Experiment's in General Chemistry," an entirely rewritten and much enlarged edition of the "Laboratory Notes." In the preparation of this book it has been the aim to adapt it especially to the course of this school; it is designed to run parallel to the recitations on general chemistry and to simultaneously serve as an introduction to the study of analysis.

Before the regular chemical experiments were taken up, a course in blowpipe analysis, preparatory to determinative mineralogy, was given.

§ 2. QUALITATIVE ANALYSIS.

The attendance of the second year class for the winter term was seven. Ten hours a week were devoted to practice in qualitative analysis, two to recitations on this subject, and one to a recitation on stoichiometry (with Mr. Sharpless). The work was a continuation of that of the fall term, Volhard and Zimmermann being the text book.

The progress of this class has fallen short of the results which experience with other classes has demonstrated to be obtainable with the methods of instruction that were employed. To a large extent this was undoubtedly owing to the very irregular attendance of the individual members, in some cases also to a want of preparation.

The first year students were occupied thirteen hours a week during the entire spring term with experiments introductory to qualitative analysis with "Eliot and Storer" as a guide.

A systematic course in qualitative analysis forms the subject of the present term with this class. Of the fifteen hours allotted to it weekly, twelve are spent in the laboratory, two are used for recitations on Fresenius's "Manual," and one for the study of "Oxidation and Reduction." This last named subject is taught by Mr. Sharpless who also renders excellent assistance in the practical instruction.

This class numbers fourteen students at present. The school's equipment for qualitative analytical work leaves but little to be desired.

§3. QUANTITATIVE ANALYSIS.

During the first few weeks of the winter term the ten students of the third year completed the study of volumetric processes. The remainder of the term was devoted to a course in methods of metallurgical analysis under Mr. Sharpless's direction.

Two special students continued to work under my own supervision in the quantitative laboratory.

At the present time four students are pursuing the regular course in quantitative analysis. For this term their work is limited to gravimetric methods, to which are devoted twelve hours per week in the laboratory and one to a recitation. The text-books used are Fresenius's "Quantitative Analysis" and Smith's "Electro Chemical Analysis." Frequent reference is made, however, to other standard works and the original literature. One of the instructors is always present and renders personal assistance when required.

In addition to those who are pursuing the regular undergraduate studies, three post-graduates are taking an advanced course in technical chemistry. As an index to the character of this work the following subjects, which have thus far been taken up, may be mentioned: Complete examination of water for hygienic and industrial purposes, analyses of fermented liquors, explosives, gases, furnace products, cobalt and nickel ores, etc.

§4. EQUIPMENT AND NEEDS.

The equipment of the quantitative laboratory has received numerous valuable additions during the past year, the most important of which are two balances built by Troemner for the department, and a Fortin's barometer. Among the desiderata which still exist, a convenient and efficient source of electrical energy, and apparatus for its control and measurement, must be especially mentioned. The electrolytic methods of depositing the metals are constantly acquiring greater importance in metallurgical analysis, and since this is one of the branches of Chemistry to which special attention must be given here, it is obvious that a complete electrolytic equipment is a necessity. Our present means of producing currents are totally inadequate, as well as wasteful and expensive. A careful study of the question has convinced me that the storage battery is best adapted to our purposes; moreover they are indispensable to the equipment of the projected electrical laboratory, so that one set of cells would meet the needs of both departments.

It is believed that the expense of a first class equipment of this kind will not exceed $300. I would propose that the batteries be placed in the charge of the instructor of electrical engineering. They could then be kept on the basement floor and be connected by wires with a suitable table provided for electrolytic work in the chemical laboratory.

Special forms of apparatus for quantitative analytical work are likewise much needed.

In conclusion I would again urge the necessity of completing the periodical sets of the chemical branch of our library, and the importance of procuring the principal works of reference.

VII.

REPORT OF THE DEPARTMENTS OF ORE DRESSING, METALLURGY, ASSAYING, AND METALLURGICAL ANALYSIS.

DR. M. E. WADSWORTH, *Director:*

In accordance with the State law, I have the honor of submitting the following report of work done in my departments between the first of December, 1890, and the thirtieth of December, 1891.

Very respectfully,

FRED F. SHARPLESS.

§ 1. ORE DRESSING.

During the fall and winter terms, September 15, 1890, to April 10, 1891, eleven students attended the lectures in ore dressing. Visits were made to all of the stamp mills of the vicinity, and each student was required to draw up a sketch, showing the method of treatment in at least one of the mills.

No good, modern text books are available for the work in this course, consequently the most of the time in the classroom was devoted to lectures upon the theory and practice of ore dressing.

During the spring term the class of eleven students devoted four weeks to practical work in the stamp mill. Twenty tons of a low grade auriferous and argentiferous quartz were treated. The students attended to the running of all machines, the instructor merely making suggestions and giving instruction when such seemed called for.

Samples of all material, entering and leaving the various appliances, were very carefully taken and assayed. The assays showed that very poor work was done at first, but that the results improved from day to day as the sources of error were found and eliminated, and as the students understood better the working of their machines.

The results obtained during the whole of the last week were as good as could be obtained in any well regulated stamp mill. A large portion of the gold and silver in our quartz was contained in the associated pyrite. All of this pyrite was collected from the stamped rock and is at the mill awaiting chlorination and lixiviation.

One of the problems, given to and solved by this class, was to determine the most economical method of obtaining the pure gold and silver from this pyrite. The results obtained were not of the highest value, because all samples experimented upon were small. The treatment best suited began with roasting, but at that time we were provided with no means for roasting samples of practical working size.

There is in process of construction, at the present time, a furnace which will accomplish this object and, indeed, is so constructed that it will be suitable for the treatment of all refractory gold and silver ores that do not require smelting.

During the present term, September 14 to December 18, 1891, four students have been enrolled for the lectures in Ore Dressing. The course of this term is being given in about the same manner that it was given during the fall term of 1890. In the spring term, however, we propose using a greater variety of ores for our work in the stamp mill.

The work of this course can never be considered complete until we have facilities for treating *all* classes of ores, and this can not be done without the addition of a metallurgical laboratory. One difficulty, we experience at present, lies in the procuring of ores just suited to our machinery. The purchasing of ores for this department would be much easier, and accomplished with greater economy, if we could use *anything* that might be offered to the School. There are many other reasons for hoping that the State Legislature will *soon* make an appropriation for this purpose, but these reasons have already been given in the Report of the Director for 1886 to 1891, page 108.

§ 2. METALLURGY.

(a) *Metallurgy of Iron, Fuel and Refractory Materials—Fall Term, September 15 to December 19, 1890.*

Eight students attended the lectures and recitations in this course.

Greenwood's "Metallurgy of Steel and Iron" was used as a text book. About half the time was consumed in recitation, while the other half was devoted to lectures bearing upon the subject. The course was conducted as outlined in the catalogue for 1889 and 1890, the lectures being illustrated with drawings of which we have quite a large number.

(b) *Metallurgy of Copper—Fall Term, September 15 to December 19, 1890.*

Ten students attended the lectures upon this subject. No text book was used, since Peters's "American Methods of Copper Smelting," the only text book available, was out of print. This text book was, however, followed closely in the lectures. The time at our disposal (two hours per week) was so limited that it was not deemed advisable to treat of other than American methods. Excursions were made to the copper smelters of this vicinity, where the practical working was observed in detail.

(c) *Metallurgy of Steel—Winter Term, January 5 to April 10, 1891.*

Six students attended lectures and recitations upon this subject. Greenwood's "Metallurgy of Steel and Iron" was used, to some extent, as a text book, but the greater portion of the time was devoted to lectures upon the theory and practice of the manufacture of steel.

(d) *Metallurgy of Lead, Gold and Silver—Winter Term, January 5 to April 10, 1881.*

Ten students attended the lectures in these subjects. The course was given entirely by lectures, no suitable text book being available. Frequent references were, however, made to the standard works, many of which are in our library. The sets of journals now in the library are, in several cases, incomplete, and it would be advisable to have these completed at the earliest opportunity.

(e) Metallurgy of Iron, Steel, Fuel and Refractory Materials—September 14 to December 18, 1891.

During the present fall term the metallurgy of steel is being given in connection with that of iron. Twenty-one students are attending the course. Greenwood's "Metallurgy of Steel and Iron" is used as a text book, but this is supplemented by daily lectures.

(f) Metallurgy of Copper—Fall Term, September 14 to December 18, 1891.

Three students are attending this course. Peters's "American Methods of Copper Smelting" is used as a text book, and we are confining the course to discussions upon the subject matter of this work.

The course in metallurgy can not be as successful as it should be, owing to the lack of practical work upon this subject. Practice in metallurgical work is just as necessary for the metallurgist as analytical work is for the chemist. The need of a metallurgical laboratory is being felt more and more every year. We are frequently in receipt of letters offering us ores for treatment, but because we lack the proper facilities we are unable to accept them.

This subject has been discussed at length in the Director's Report for 1886–1891, and what is there said cannot be too strongly insisted upon.

13. ASSAYING.

The course in Assaying occupies seven hours in each day for two weeks in the spring term.

During the spring of 1891 twelve students were instructed in assaying. No text book was used, but notes were printed by the instructor and furnished each student. Almost all of the time was devoted to laboratory practice, only a few hours being given to lectures.

Assays were made of lead ores, gold and silver ores, and copper "mineral;" altogether about seventy-five determinations were made. While the work in the stamp mill, which follows that of the assay laboratory, was in progress, twelve samples of the crushed quartz were assayed daily. Numerous assays were also made in connection with the experimental work, while determining the best method for working our ore; so that the course in assaying lasted, practically, throughout the entire spring term.

This laboratory is well equipped, and until the growth of the school demands the present laboratory for other purposes, nothing except the regular annual supplies need to be procured.

There is always some danger of fire from this department; and, though every possible care is taken, I would advise, for the safety of the main building and convenience of the department, that the assay laboratory be moved to the metallurgical building as soon as one is erected.

14. METALLURGICAL ANALYSIS

During the winter, January 5 to April 10, 1891, eleven students were pursuing this course. The work was carried out just as indicated in the catalogue for 1890-91; twelve hours a week being devoted to laboratory practice in Metallurgical Analysis, with exception of the first two weeks, which time was devoted to Volumetric Analysis.

The object of this course is to acquaint the student with the special methods of analysis that are in use in the laboratories of metallurgical establishments. Special prominence was given to the assay and complete analysis of iron ores, pig iron, and steel, the determination of their ingredients carbon, silicon, phosphorous, sulphur and manganese, the analysis of fuel, cinder, limestone, etc. The student was taught not only to perform the determinations *accurately*, but also to work as *rapidly* as was consistent with the desired degree of accuracy. Complete sets of apparatus were procured and constructed for this work.

Owing to the fact that methods used in technical laboratories change materially from year to year, no text book was used. Detailed printed directions were furnished to serve as a guide; these were printed just previous to the work on each subject, and contained the shortest and best methods known up to date, with references to the original papers, the most of which are to be found in our library. The course has proved to be both popular and instructive, several special students having elected it as the major portion of their work.

Additions to the apparatus for this work should be made from year to year, in order that we may keep pace with all advances made in this most important branch of our practical

VIII.

REPORT OF THE DEPARTMENT OF MECHANICAL AND ELECTRICAL ENGINEERING.

DR. M. E. WADSWORTH,
Director of the Mining School:

DEAR SIR:—I transmit herewith a report of the courses of instruction given in this department, together with such changes and additions as have been made since December 1, 1890.

Yours very truly,

EDGAR KIDWELL.

November 16, 1891.

II. DRAWING.

The course in drawing, as outlined in my previous report, has now gone into effect; so far as we have been able to test it, excellent results have been obtained, hence no changes of consequence will be made during the present school year. During the year 1892-93, Thorne's "Course in Mechanical Drawing" will be adopted as a guide for practical work in the drawing room, in place of Warren's books now used. Lectures and recitations will be based on a series of notes compiled from Angel's "Practical Geometry and Construction."

The following schedule shows the distribution of work during the three years:

First Year.

Description, preparation and testing of drawing instruments and materials; graphical solution of plane geometrical problems, methods of arranging drawings on sheet, tinting, and harmony of colors. (Warren's "Drafting Instruments and Operations," supplemented with lectures.) Projections; intersections of lines and surfaces; development of surfaces; elevations; sections; lettering of various kinds, such as Roman, Italic, Gothic, block and round writing; borders for drawings. Warren's "Elementary Projection Drawing," with lectures. Topographical drawing; making scales; methods of plotting surveys, by protractor and rectangular coordinates; topographical signs. Fall term, ten hours per week; winter term, eight hours per week.

Second Year.

Isometric and cabinet projection; the theory of construction drawing; figuring and line shading; tracing and blue printing; the use of bond paper; machine sketching, and the production of complete working drawings from model, or rough sketches furnished by the instructor. A system of recording drawings is also taught. (Lectures and work in drawing room.) Fall term, four hours per week; winter term, three hours per week.

Third Year.

Graphical Statics. Analysis of roof trusses of various standard designs. (Greene's "Roof Trusses," supplemented with lectures.) Fall term, four hours per week.

Designing. Lectures and work in drawing room. Winter term, six hours per week.

Prominence is given in this course to the designing of girders, columns, shafts, floors for heavy loads, framing, trestles, etc. Special attention is also given to designs for long lines of steam-pipe, line and counter shafting for various duties, etc. No design is accepted unless accompanied with complete working drawings and bill of materials.

Accuracy, neatness, and a thorough understanding of the work in progress are insisted upon at all times, and no sheet will be accepted which would not pass in the average drafting room.

During the entire course, all drawings accepted by the instructors are considered as the property of the school, and are bound and deposited in the library.

The Topographical Drawing is under the personal supervision of the Instructor of Surveying, and is arranged with special reference to the practical work in plane and mine surveying.

The following table shows the attendance in this class:

Terms	First Year Students	Second Year Students	Third Year Students	Totals
Fall term '90	28	6	.	34
Winter term '91	24	6	6	36
Fall term '91	35	10	8	53

The instruction in Graphical Statics scheduled for the fall term to the third year class was given to the graduating class of 1891 during their second year, which accounts for the blank in attendance of third year class in the fall term of 1890.

Two of the students enrolled above entered for Drawing only, and are now pursuing a special course in that branch together with such other work, in Mathematics and Physics, as I considered advisable for them to take.

The number of desks in the drawing room last year was found to be insufficient to accommodate the large number of students who matriculated this term. These desks have therefore been re-arranged, to economize space, and three new drawing tables with a number of improvements over the old design have been addded to the equipment of the room. We can now accommodate sixteen students more than formerly, but no further addition of desks can be made in the future as every available foot of floor space has been taken up.

(*a*) In my last report I stated to you the urgent necessity for an efficient blue printing outfit as a part of the equipment of the drawing room. During the last summer a frame capable of making a print three feet by four feet has been designed by this department, and though its completion has been delayed by our other duties, we expect to have it in operation by December 1. This frame is arranged to swivel to any any desired angle, and is carried on a truck which will roll on tracks supported by outriggers seven feet long, thrown from middle window on west side of the drawing room. Every detail has been carefully studied out, and it is believed that this frame will be excelled by none in use in any other technological school. A new slate vat 24 inches x 48 inches x 7 inches with the necessary attachments has also been added to the equipment of the drawing room, and will be used for developing the blue prints.

§2. MECHANICAL ENGINEERING.

The course in this branch, as given in my last report, went into effect at the beginning of the present term. So long as the three years' course is adhered to I do not see how we can devote to Mechanical Engineering any more time than herein specified without overburdening the students, or curtailing the instruction in some other branch equally important. Should the four years' course be adopted, the work in this department can be made much more efficient, by a better grading of subjects, and, by reason of the increased amount of time available, some unavoidable gaps in the present course can be filled up. The greatest *desideratum* at present is increased time for practical work in the testing laboratory.

The following is a detailed statement of the course of instruction:

Second Year.

(*a*). *Properties of Materials of Engineering.*—Lectures on cast and wrought-iron; steel; copper, and its most important alloys; tin; zinc; antimony; bismuth; timber; and lubricating oils. Fall term, two hours per week.

The course includes a full discussion of the various grades of material, methods of manufacture, forms in which it appears in the market, their adaptation to the purposes of the engineer, methods of preserving materials from corrosion, decay, etc. The course is supplemented by practical work in testing.

Fourteen students took this course last year, and eighteen have already entered this term's work.

(*b*). *Mechanism.*—Laws of motion; linkwork, cams; teeth of wheels, with use of odontograph; wheels in trains; aggregate motion; miscellaneous problems in Applied Mechanics, with applications. Determination of proper sizes of pulleys, belts, etc., for particular duties. (Goodeve's "Elements of

Mechanism," supplemented with lecture models, and machinery in shops and laboratory.) Winter term, four hours per week.

Six students attended this course last year, and twenty are expected to attend next term.

(*c*). *Shop Practice.*—Chipping, filing, scraping, general vise work, forging, pipe fitting, and use of machine tools. Woodwork, such as making the various kinds of joints, finishing and polishing, turning, pattern making, etc. Discussion of the various kinds of tools used for wood and metal work. Summer term, thirty-five hours per week for eight weeks.

No instruction in shop work was given during the last summer, owing to rearrangement of the course. Eighteen students already on the rolls will take this course next summer, in addition to those expected to enter for shop work only. All work done in shops is to blue prints made in the drawing room. The leading object kept in view when assigning each exercise, is to impart knowledge to the student, but an endeavor is also made to utilize the product of the shops, by planning it with reference to the needs of the school, when it can advantageously be done. This method of conducting practical work has been found to be the most efficient, hence such models of valves, link motions, mechanical movements, etc., as are needed for lecture purposes, will be made by the students.

To familiarize the students with the operation and care of machinery, each one will be detailed from time to time to fire the boiler, run the engine, clean and oil the machinery, and to perform such other duties as the instructor in charge may assign to him.

In pursuance of the policy outlined in my last report, arrangements have been perfected whereby at the beginning of the summer term of 1892, and thereafter, persons desiring to take the shop work only, will be admitted as special students, on presentation of evidence that they can pursue the course with profit. Application for such special work should be made to the Director, or to Mr. Kidwell, not later than July 1. It is believed that this new departure will be of material assistance to many young men who are unable to take our full course.

Further information concerning the shops is given at the conclusion of this section.

Third Year.

(*d*). *The Steam Engine, and Allied Subjects.*—An elementary course in thermo-dynamics of air and steam engines; the relation between the size and power of an engine; the mechanics, mechanism, and details of steam engines; valves and valve gears; indicator diagrams, their interpretation and methods of working them up; the various kinds of boilers, their fittings, and the relative proportions of their various parts; fuel, and combustion; condensation and condensers; the influence of compounding cylinders; testing of engines and boilers (Holmes's "The Steam Engine," supplemented with lectures and laboratory practice on Saturdays). Four hours per week first half, five hours per week, second half of fall term; three hours per week, winter term.

(*e*). *Engineering Appliances.*—Lectures on steam pumps, gauges, lubricators, safety valves, steam pipe and fittings, boiler and pipe coverings, belting and packing, discussion of instruments used in testing, such as Prony brake, various kinds of dynamometers, steam engine indicators, speed counters, polar planimeters, etc. (Trade circulars and testing apparatus in laboratory.) Winter term, one hour per week.

Eight students attended this course last year. Those who should have entered this term not having yet made up their conditions, instruction will not be given in this class for several weeks.

(*f*). ***Mechanics of Materials.***—Application of the principles of statics to rigid bodies; elasticity and resistance of materials; cantilevers; simple, restrained and continuous beams; bodies of uniform strength: riveting; torsion of shafts; combined stresses; designing of beams, columns and shafts, in wood and metal. (Merriman's "Mechanics of Materials," supplemented with lectures.) Three hours per week first half, two hours per week second half of fall term.

(*g*). *Testing of Materials of Engineering*—Such as wrought and cast iron, steel, brick, stone and slate. Lectures, recitations, practical work in the laboratory on Saturdays. Each student makes a series of tests in tension, compression, and cross-breaking, on laboratory testing machines.

This subject has been under the control of this department only since the beginning of the present fall term. Two students are now taking the course, another is expected in a few days, and by special arrangement between students and instructor four hours per week will be devoted to this study during the present term.

§ 3. The re-arrangement of the work shops necessitated by the increased number of students has begun, and will be completed in time to open the summer course in shop work. Some of the machinery has already been moved, bids for new work benches have been obtained, the posts, hangers, etc., needed for re-constructing line shafting have been contracted for, and delivered. The part of the pattern shop formerly occupied by the Assay Department has been floored over, the cement floor of testing room has been completed, and partitions between pattern shop and testing room are nearly finished. The Edison dynamo now in the stamp mill will be removed to this department in a few days.

The former plan of employing the stamp mill boiler to furnish the steam for the laboratory, and shop engine, was not only extremely inconvenient and uneconomical, but fraught with danger, unless an additional instructor were employed to take charge of the steam plant while the shops were in operation. When students are learning to manage engines and boilers, proper precautions for safety require the instructor to be with them continually. When conducting tests, etc., with students, it is essential that the boiler and engine be fairly close to each other, as any different management requires a larger force of instruments than we can command here. For these reasons, we have designed a system of piping by which one of the boilers used for heating can be employed to furnish power, yet be available on fifteen minutes' notice for heating, should a necessity for such use arise. This boiler will be provided with both spring pop and lever safety valves, and every appliance to insure safety when in operation.

§ 4. The stock of tools on hand, as left by my predecessor, has been carefully gone over, stamped or etched with name of the school, and shop number, and recorded. This will enable us to estimate the number of tools needed to complete the equipment of shops for the summer course. The following additions have been made to the equipment of this department since December 1, 1890. One Tabor indicator, with pantagraph, three-way cocks, and several extra springs, one Ashcroft oil testing machine, two polar planimeters, two extra springs for Crosby indicator, one 2,000-pound Olsen cement testing machine, arranged for tension, compression, and cross-breaking tests, a set of pipe fitting tools up to two inches, an assortment of thermometers for testing, a speed counter, boiler test pump, and several small instruments. A steam gauge tester, designed by this department, is also under construction.

Micrometers for use on the testing machines are in course of design, and will be constructed when our time will permit us to do so.

§ 5. I take great pleasure in acknowledging the following donations to this department. One nickel-plated sectional model of No. 4 Körting Universal Double-Tube Injector, by L. Schutte & Co., Philadelphia; one No. 10 Hancock Inspirator, by Mr. Charles Gibbs, Houghton; one sectional model of injector, by Penberthy Injector Co., Detroit; one sample board of electric wires and cables from the International Okonite Co., New York, and same from the Standard Underground Cable Co., Pittsburg, Pa.; detail drawings of roof trusses in United States Court-house and Postoffices at Baltimore, Md., and Shreveport, La., by Supervising Architect, United States Treasury Department, Washington; one sectional model of No. 15 Hancock Inspirator, by the Hancock Inspirator Co., Boston; one eight and one-half inch full-nickled skeleton dial steam-gauge, by the Star Brass Co., Boston; one complete case of drawing instruments, by Messrs. Theo. Altender & Sons, Philadelphia. Other donations have been promised by several firms. We are of the opinion that when manufacturers have become better acquainted with the advantages secured by them in placing samples or models of their specialties in this institution where they can be seen and studied by those who, in the future, will be called upon to use just such material, our list of donations will increase.

§ 6. When the work herein mentioned has been completed, it will be impossible while the laboratories remain in the present building to resort to any other arrangement to render more efficient the instruction given, or to accommodate a greater number of students. Every available foot of space has been occupied, and yet we have been unable to make proper provision for giving the amount of practical instruction which should accompany our class-room work. Though by using one of the heating boilers for power we have removed one great inconvenience, many others remain. We have no place in which to locate a planer for the pattern shop, a steam pump, or condenser for the laboratory engine. The machine shop is separated from pattern shop by a hallway over thirty feet long, and the boiler room is inconveniately located with reference to both. The business of instructors is to teach, and any arrangement of shops, laboratories, or class rooms, that keeps an instructor continually on the march, will fritter away time which ought to be given to his students. We cannot afford to hire a separate instructor for both shops, boiler room and testing room, yet the present arrangement of our quarters seems to require such a course, if we are to use to its greatest efficiency the material we have under our charge. While these evils exist, much of our work will necessarily be inoperative, and I would therefore recommend that all the shops be provided for by the erection of a suitable building especially planned for this purpose. The shops could then be located to suit our requirements, and the engine and boiler room could be placed so as to be convenient to shops, stamp mill, and metallurgical laboratory. I would further recommend that if this building is erected the boiler room should be designed not only to furnish all the power needed by the various departments of the school, but also to accommodate the heating boilers in the main building. Sufficient space for storage of fuel to last at least two months and even the entire winter, if possible, should also be provided. The present plan of having the boilers in unsuitable places, and hauling fuel to the school every few days in all kinds of weather, is not only extremely inconvenient, but very expensive, and should not be allowed to continue.

The rooms now occupied by the pattern and machine shops could at a trifling expense be converted into four or six class rooms, equal in size and convenience to any class rooms now in use in this school. Whether or not such change is made, another class room will have to be provided very soon for this department, as the present lecture-room for Mechanical Engineering has not sufficient seating capacity for the class which entered the school this term.

§ 7. ELECTRICAL ENGINEERING.

In my report of last year I gave fully the urgent reasons why an electrical laboratory should be provided in this school, and my experience since that report was written has only confirmed what was therein said. I consider it impossible to accomplish any valuable results in this work without laboratory practice, and in this I think I will be supported by every one who has had experience in giving such instruction. Owing to the failure to secure appropriations for a laboratory, I shall be obliged to continue giving instruction in electrical engineering by means of text-books, lectures, and recitations. The course now given is as follows.

Second Year.

Electrical Instruments and Measurements—Discussion and measurement of current, electrometric force, quantity, density, resistance and insulation, commercial ammeters, voltmeters, resistance sets, condensers, etc.; power and its measurement. (Ayrton's "Practical Electricity," with lectures.) Two hours per week, winter term.

Third Year.

Electrical Engineering—Electro-magnets, and electro-magnetic induction; theory of the dynamo, both direct and alternating current, with discussion on the typical forms in general use; motors and their applications; transformers; storage batteries; electrical fittings, wiring, etc. (Slingo and Brooker's "Electrical Engineering," with lectures.) Three hours per week, fall and winter terms.

Eight students took this course last year, and eighteen are expected to enter the second year work next term.

§ 8. The heating apparatus having been placed under my charge, I would report that at the end of the past summer term the boilers were carefully inspected, and put into good condition. The fire brick lining was entirely renewed, and a new set of straight cast iron grate bars was substituted for the patent grate formerly in use, which was found unsatisfactory. The uptakes were badly designed by the contractors, and we have made plans for altering them, and expect to have the changes made in a few weeks. When these repairs are completed, the boilers will be in as good condition as is possible while they remain in their present location in the main building. Owing to the oversight of the architect of the building in providing only one flue for all the boilers, it will be impossible to secure, without undue expense, better results than we are now obtaining. Lack of storage room for fuel continues to cause us much inconvenience, but there seems to be no satisfactory method for providing for such room unless a new building is erected.

IX.

REPORT OF DEPARTMENT OF MINING.

DR. M. E. WADSWORTH, *Director*.

DEAR SIR—I herewith submit a report of the work done in the Mining Department between December 1, 1890, and November 30, 1891.

Yours very respectfully,
F. W. DENTON.

§ 1. MINING AND MINE SURVEYING.

The course of mining as given the past year occupied two hours per week during the fall term, and three hours per week during the winter term. In addition to this, the entire six weeks of the spring term were spent in study at the mines in the Marquette and Menominee regions.

The work during the fall and winter consisted mostly of lectures and other class room work in mining, although a few

Saturday excursions to neighboring mines were made at the beginning of the course.

(*a*). The lectures embraced the following subjects: Surface Excavation, Explosives, Drilling (hand and machine), Blasting, Air Compressing and Air Compressors, Prospecting, Opening and Developing of Typical Classes of Deposits, Surface and Underground Transportation, Ventilation of Mines, Hoisting, Mine Accounts.

These subjects were treated as thoroughly as it was possible with the hours allowed. Owing to the want of time very few recitations were required, and the whole course was necessarily somewhat abbreviated as regards details.

These defects can be overcome for the future, since nearly double the time has been allotted to the subject.

(*b*). The general plan of the course, as conducted in the past year, and as it is intended to conduct it during the coming year, is first to present to the students the principles as clearly and accurately as possible, and to follow with the modern applications of these principles.

Where it is deemed profitable, the history of the depelopment of certain departments of mining is given: For example, the development of modern machine drills, air compressors and hoisting machinery is studied with some minuteness. In other branches the main work is the study of the best modern practice as found in the United States.

Very little time is devoted to the study of mining as carried on in foreign countries.

While the exclusion of study of foreign practice and foreign machinery from the course has received some adverse criticism, it is still considered to be the best for the students that attend the school. If more time were available, then the introduction of foreign practice would certainly be advisable.

At present this could be done only by shortening the study of domestic practice, and it is not deemed expedient to do this.

The additional time allowed for this course during the coming year will be utilized for the further extension of the work along the same lines, and for the holding of recitations. During the past year the method followed in illustrating the lectures was that of large diagrams, which the students were not allowed to copy at the time of the lecture. Negatives, each containing four of these diagrams, were made by me, and these negatives were accessible to the students for the purpose of making blue prints from them.

No charge for the use of negatives and printing frames was made, so that the only expense to the student was the cost of the blue print paper and the small amount of time necessary to make the prints.

This system allows the student to give his undivided attention to the lecture and to the taking of written notes, while the blue prints may be inserted in the note books to accompany the written description. At the same time the labor of the department is confined to the making of the diagrams and the negatives.

This system will be followed for the coming year. With the photographic laboratory which is to be established, it will be possible to further illustrate the lectures by means of lanterns.

The laboratory will also greatly assist the making of diagrams.

The system of lecturing that will finally be adopted is yet undecided upon.

(*c*) The class of 1891 spent the six weeks of the spring term, as already stated, in the Marquette and Menominee regions.

The first two weeks were occupied almost entirely in making a survey of the Volunteer Mine at Palmer, Mich.

The survey was designed to give practice in ordinary mine surveying and consisted in running a closed survey from the surface through an inclined shaft into the mine and connecting again with the surface by means of a vertical shaft. The computations and maps were afterwards made.

The instruments were then returned to the school, and the class began the study of mining as practiced at the Lake Angeline Mine, near Ishpeming. For this work large note books were provided and the students were required to make sketches and notes, describing in detail the methods followed at this mine.

The third and fourth weeks were thus occupied.

The fifth week was spent in visiting other mines in the immediate neighborhood, where different systems of mining were followed. The mines visited were the Lake Mine of the Cleveland Iron Mining Co., Barnum Mine, Lake Superior Soft Ore Mine, Buffalo and Queen Mines, Ropes Gold Mine.

The sixth and last week was spent at the Chapin Mine, Iron Mountain, Mich., where underground and surface transportation and hoisting could be seen conducted on a much larger scale than elsewhere in this region.

It will be my policy in conducting this work at the mines in the future, to spend the first one and one-half to two weeks at some mine well adapted for surveying in, and then to remove to a large mine to study in detail its operations, until the last week of the term. This last week will be occupied in visiting for a day at a time different mines in the vicinity, noting, as far as possible, the peculiar characteristics of each. This is considered to be a better method than to try and visit as many different mines as possible in the six weeks allowed.

§ 2. PLANE SURVEYING.

Plane surveying occupies two hours per week during the winter term and eleven weeks of field work in the summer term.

This course was conducted during the past year in the manner explained in my last report, and the same system will be followed for the coming year.

The class room work of the winter term is devoted entirely to the study of methods of making computations and maps. For this work "Davies' Surveying" is used as a text-book.

During the summer term surveying instruments and methods are studied, using Johnson's and Searle's books as guides.

The surveys as published in the catalogue were executed by the class, excepting "the subdivision of a section" which for want of time was omitted.

§ 3. TOPOGRAPHICAL DRAWING.

Instruction in this subject is given in connection with the surveying of the winter term, and practice is had in the drawing room during eight hours per week for eight weeks of the winter term This practice consists chiefly in copying standard sheets of topographical drawings, and of plotting surveys from the field notes.

§ 4. HYDRAULICS.

Merriman's text-book is still used for teaching this subject.

It is hoped that during the coming year a collection of hydraulic machinery will be started. Such a collection would greatly increase the value of this course, which is now entirely dependent upon books and diagrams.

X.

STRATIGRAPHICAL GEOLOGY AND PALEONTOLOGY.

Alfred C. Lane, Instructor.

This course was given during the fall and winter terms of 1890-91 to a class of six men, of whom only three were regularly in the course for the whole time. A sufficient knowledge of zoölogy and paleontology was given by lectures, —hektographed abstracts were a great help to the students— to enable them to read the prescribed parts of Geikie's "Text-book on Geology," with profit. Toward the end of the course the students showed considerable ability to assign fossils to their periods, and to indicate on blank maps the distribution of the important formations in the United States. The collections have had some valuable additions from D. A. McCord, Mrs. Blandy, and others. A large portion of the students' time was devoted to working on the labelled and unlabelled specimens in the collection, the same as is done in the course in mineralogy.

The wall charts and geological maps, which are used in illustrating this course, should be hung like window curtains from the ceiling, so as to be both readily accessible and out of the way.

The course was omitted in the fall of 1891, in order to complete the work in mineralogy.

XI.

PETROGRAPHY.

Alfred C. Lane, Instructor.

This course was given during the fall and winter terms for three hours a week to a class of fifteen, of whom three were in the course only for part of the time. In addition, private instruction was given to one pupil. The instruction was hampered in the beginning by delay in delivery of the microscopes beyond the time contracted for. It is also thought that more hours a week for a shorter time would sustain the interest better, and the course will in future be so given.

The methods of instruction were given in last year's report. I have only to add, that synoptical tables have been prepared, and by previous publication in the "American Geologist" have been rendered accessible to the students at moderate cost. The hektograph has also proved very valuable in lightening the burden of note taking. The laboratory equipment is now practically complete and equal to any in the country, and tables have been introduced so as to give the utmost economy of light. The only important apparatus yet wanting is a projection lantern, for which we are now in negotiation.

DR. M. E. WADSWORTH,
Director of Michigan Mining School,

DEAR SIR:—In accordance with the Statute I have the honor of submitting to you herewith a report of my Department.

Respectfully,
ROBERT IRWIN REES.

§ 1. The number of books in the library of the Mining School is seven thousand six hundred and ninety eight, with about one-third as many pamphlets. Of these eighteen hundred and five are Congressional Documents, Michigan Legislative Documents, and a few other volumes on non-technical subjects, which have been received as gifts by the library. The remaining portion has been almost entirely obtained by purchase. The reading room is well supplied with the current numbers of the leading scientific periodicals and technical journals, the volumes as completed being bound and placed in the library for permanent use. Our subscription list now numbers one hundred and twenty-six.

The choice of books has been made with a view to their application to the subjects taught in the school; and as the means have been very limited, only such purchases have been made as would bear most directly upon the needs of the instructors in their several departments and of the students for reference. We have therefore a purely technical and scientific library in its strictest sense.

(*a.*) The students are allowed as free use of the library as may be under existing circumstances. With certain limitations they are permitted to take any book from the library, except some of the more general works of reference. The issue of books has greatly increased during the past year, particularly during the present fall term. There is one thing, however, which greatly detracts from the efficiency of the library, and that is the lack of knowledge on the part of the students as to the contents of the library. It is the work of the librarian at present to endeavor to obviate this difficulty.

(*b.*) To this end a beginning has been made toward the preparation of a complete card catalogue to which the students can have free access. But so much of the librarian's time has been taken up with his other duties, that the work in this direction has moved but slowly. It is hoped that it will be completed by the opening of the fall term of 1892. The card catalogue, when finished, will be a complete dictionary catalogue, embodying in one alphabetical list a subject, author, and a partial title catalogue. The system is based upon Cutter's "Rules for a Dictionary Catalogue." The books will also be classified and re-arranged on the shelves so that a permanent shelf number may be given to each book, and so that any book can be readily referred to on the shelves. When this work has been completed it will greatly increase the usefulness of the library.

(*c*). While it will be seen that a fair beginning has been made towards the formation of a library, the collection of books which we now have is but a nucleus upon which to build a library such as the instruction given in an institution of this character demands. As you have already said, "the library is the right arm of every teacher in the school," and until they are given the means for the full exercise of this member, the instruction in all the departments will be much less efficient than it would be otherwise. The needs of all the departments in this direction are very great. The department of Mining Engineering is perhaps best supplied with works relating to its course; but there should be many additions made to the literature relating to the courses of all the departments. There is a particular need for large works of reference and some of the more important transactions and proceedings of scientific societies, and complete sets of scientific journals. As the march of science is steadily advancing, so is it necessary that every teacher of science should keep up with the pace; but in no way can he do so other than by having access to the literature upon the subjects to which he gives his attention. It is obvious then that the library alone can supply him this need. It will be seen how important is the function which a library of this character fills; for while each department has its own special courses to conduct, the library to a great extent embodies them all in one. It is therefore earnestly urged that in the future full provision be made for its growth, support and maintenance.

PART II.

REPORT OF THE DIRECTOR

OF THE

MICHIGAN MINING SCHOOL

FOR 1891–1892.

TABLE OF CONTENTS.

§ 1. Appointments and Resignations.
  (*a*). Dr. Harry F. Keller.
  (*b*). Dr. George A. Koenig.
  (*c*). Requisites for success in an instructor.
§ 2. Students in the School.
  (*a*). Summary for 1891–1892.
  (*b*). Summary for 1892–1893.
  (*c*). Average age of students.
  (*d*). Birthplace of the students and of their fathers.
  (*e*). Occupation of the fathers of the students.
  (*f*). Schools at which students have fitted for the Mining School.
§ 3. Comparative Growth of the Mining School.
  (*a*). Discipline in the Mining School.
  (*b*). Reduction of numbers.
§ 4. Graduates.
  (*a*). List of students who nearly completed their course.
§ 5. Changes in the Course of Instruction and Requirements for Admission.
  (*a*). Length of the course.
  (*b*). Requirements for admission.
  (*c*). Electives.
§ 6. Needs of the Mining School.
  (*a*). Mathematics and physics.
  (*b*). Secretary of the Mining School.
  (*c*). Treasurer and Purchasing Agent.
  (*d*). Requisitions.
  (*e*). The Director's duties.
  (*f*). The remedies for the evils.
  (*g*). Assistants in the School.
  (*h*). Endowment.
  (*i*). Gymnasium.

§ 7. Appropriations.
    (*a*). Salaries.
    (*b*). Technical education.
    (*c*). Annual appropriations.
    (*d*). Appropriations for new building and equipment.
    (*e*). Property of the Mining School.
§ 8. Instruction under the charge of the Director.
§ 9 Report of the Professor of Mathematics and Physics.
§ 10. Report of the Professor of Chemistry to September, 1892.
§ 11. Report of the Professor of Chemistry from September, 1892.
§ 12. Report of the Professor of Metallurgy.
    (*a*). Ore dressing.
    (*b*). Technical chemistry.
    (*c*). Metallurgy.
    (*d*). Assaying.
    (*e*). Photography.
§ 13. Report of the Professor of Mechanical and Electrical Engineering.
    (*a*). Drawing.
    (*b*). Mechanical Engineering.
    (*c*). Electrical Engineering.
    (*d*). Shopwork and Engineering building.
§ 14. Report of the Professor of Civil and Mining Engineering.
    (*a*). Mining.
    (*b*). Hydraulics.
    (*c*). Plane Surveying.
    (*d*). Topographical Drawing.
§ 15. Report of the Instructor in Petrography.
    (*a*). Petrography.
    (*b*). Economic Geology.
    (*c*). Paleontology and Stratigraphical Geology.
§ 16. Report of the Librarian.
§ 17. Report of the Board of Visitors.

REPORT.

To the Honorable, the Board of Control of the Michigan Mining School:

GENTLEMEN :—The Director of the Michigan Mining School has the honor to submit to you the following report for the year 1891-1892, which will, in some respects be brought down to date.

Very respectfully,

(Signed) M. E. WADSWORTH.

APRIL 3d, 1893.

§ 1. APPOINTMENTS AND REGULATIONS.

During the past year the following changes have been made in the officers of the school or in their relative positions.

Messrs. Kidwell, Sharpless and Denton, were advanced to the rank of full professors in their respective departments, commencing September 15th, 1892.

Mr. Carroll L. Hoyt, M. E., a graduate of Cornell University, was appointed to the instructorship in Mechanical Engineering and Drawing, made vacant by the departure of Mr. Rowland.

(*a*). A very serious loss to this institution was occasioned, last summer, by the resignation of Dr. Harry F. Keller, for personal and family reasons, which necessitated his residence in the east. He had proved himself an excellent instructor, earnest, capable and trustworthy, and possessed of good executive ability. To him is due much of the rapid advance the school has made in the past two years, and his departure from this institution is regretted by all.

(*b*). Owing to the decision of the trustees of the University of Pennsylvania to give up the course in Mining Engineering in that institution, this school was fortunate enough to secure, through the kind offices of Dr. Keller, the services of Dr. George A. Koenig as Professor of Chemistry. Dr. Koenig had had the general charge of the course in Mining Engineering in the University of Pennsylvania, and had had a long and varied experience both as a teacher and in practical work. Dr. Koenig is a graduate of the University of Heidelberg, and of the Mechanical Engineering course in the Polytechnicum of Karlsrhue. He also studied in the University of Berlin and in the Mining School of Freiberg. He certainly has had a very broad and extensive education and experience, and the question of his success would seem to depend upon this problem, which has to be solved wherever any man, old or young, is taken from one institution, and transferred to another.

(*c*). Can a teacher adapt himself to the changed conditions that surround him in a school new to him, and meet the needs of the latter and of its students? Rarely, if ever, can success come to any one unless he can remold himself sufficiently to harmonize with his environment, a process that requires great care and labor if the change of location is made at a time when one is well on in middle life. If one can retain that power of adaptability, then success can be considered almost certain. This requires that a teacher should familiarize himself with the needs of the region in which his school is located, the constituency from which its pupils are drawn, the nature and thoroughness of their preparation, their home surroundings and culture, their intellectual ability, their prospective work and station after graduation, their habits, etc. The instructor then should adapt his teaching to the previous training of the pupils under him, and from that point lead them on, by methods applicable to their intellectual capacity, to the place they ought to reach before they commence their life work. Every teacher must first place himself on a level with his pupils, if he wishes subsequently to lead them to, or to place them on, a higher plane than the one they previously occupied.

§ 2. STUDENTS IN THE SCHOOL.

The Board has reason to congratulate itself on the increased attendance upon the school during the past year, as shown below in summaries of all the students in the school since the last session of the legislature. From these summaries it can easily be seen that Michigan furnishes by far the largest number of the students. In 1891–92, fifteen; 1892–93, twenty different countries and states were represented by pupils here which shows a decided gain in reputation of the school abroad, when we remember that in 1889–90 but seven states had pupils here. Of these Wisconsin has always had most, as her people are greatly interested in Michigan's mines.

The average age of the students can be seen, by the table, to be quite high, being 21 to 22 years. This is an encouraging sign, as the work is of a high grade and requires the matured ability of a man rather than that of a boy.

(*a*.) SUMMARY.

1891–1892.

Graduate students	8
Class of 1892	2
Class of 1893	16
Class of 1894	34
Special students	18
Total	78

BY COUNTRIES AND STATES.

California	1
Canada	1

Colorado		2
England		1
Idaho		1
Illinois		1
Indiana		1
Michigan	Upper Peninsula 34 Lower Peninsula 23	57
Montana		2
New York		1
Ohio		1
Pennsylvania		1
Peru		1
Utah		1
Wisconsin		6
Total		78

(*b.*) SUMMARY.

1892–1893.

April 3, 1893.

Graduate students	3
Class of 1893	14
Class of 1894	26
Class of 1895	38
Special students	11
Total	92

BY COUNTRIES AND STATES.

Alabama		1
Canada		1
Colorado		2
Cuba		1
England		2
Idaho		1
Illinois		2
Indiana		1
Michigan	Upper Peninsula 41 Lower Peninsula 21	62
Minnesota		3
Mississippi		1

Missouri	1
Montana	1
New Brunswick	1
New Jersey	1
New York	1
Ohio	3
Oregon	1
Pennsylvania	1
Texas	1
Wisconsin	5
Total	92

(c.) AVERAGE AGE OF STUDENTS.

Special students	22 years.
Class of 1894	20 1-2 years.
Class of 1893	21 1-2 years.
Class of 1892	24 years.
Graduate students	24 years.
Average age of all students	21 1-2 years.

1892-1893.

April 3, 1893.

Special Students	22 years.
Class of 1895	21 years.
Class of 1894	21 years.
Class of 1893	23 years.
Graduate Students	24 years.
Average Age of all Students	22 years.

The number of students enrolled brings the School up to about its limit of capacity, as only ninety to one hundred students can be accommodated in the present quarters, and these only with difficulty. The number of the pupils has been kept down by rigid work, dismissals, etc. At no time during the first eleven years of its existence did the University of Michigan have as many pupils as the Mining School now has, and even as late as 1869 the Agricultural College had fewer, although that institution had been established twelve years. The success of this School compared with others, has demonstrated the wisdom of its being located in a mining district, the excellent policy of its Board of Control, and shows that the practical nature of its course of instruction is approved by those that seek a mining engineering education.

(*d*). Tables are here given showing the birthplaces of the students and of their fathers. These show that the majority of the pupils are of Michigan birth, but that New York, England and Canada lead as the birthplaces of the fathers. In like manner, if we consider the occupations of the fathers, the table shows that of the forty-six occupations by them, the farmers lead in numbers as they have done for several years.

NUMBER OF STUDENTS BORN IN EACH STATE OR COUNTRY.

April 3, 1893.

Alabama	1
California	1
Canada	5
Cuba	1
England	5
Illinois	4
Indiana	1
Iowa	1
Michigan	52
Minnesota	2
Mississippi	1
Missouri	1
New Jersey	1
New York	6
Ohio	3
Oregon	1
Pennsylvania	2
Wisconsin	4
	92

BIRTHPLACE OF FATHER.

April 3, 1898.

Austria	1	
Canada	11	
England	14	
Germany	7	
Ireland	4	
Scotland	6	
Sweden	1	
Total	44	
United States.		
Indiana	1	
Maine	2	
Massachusetts	3	
Michigan	8	
New Jersey	1	
New York	22	
North Carolina	1	
Ohio	1	
Pennsylvania	3	
Rhode Island	1	
Virginia	1	
Vermont	2	
West Virginia	1	
Wisconsin	1	
Total	48	92

OCCUPATION OF FATHER.

April 3, 1898.

Banker	2
Book-keeper	2
Butcher	1
Carpenter	4
Chemist	1
Clergyman	2
Clerk	1
Copper refiner	1

Cotton raiser	1
Deceased	5
Engineer, stationary	2
Farmer	11
Insurance	2
Jeweler	1
Journalist	1
Justice of the Peace	1
Laborer	1
Lawyer	4
Lumberman	6
Machinist	2
Manufacturer	1
Marshal	1
Master mariner	1
Master mechanic	2
Mechanical engineer	1
Merchant	7
Millwright	1
Mining	3
Mining captain	2
Mining engineer	1
Mine superintendent	3
Mine surface laborer	1
Overseer	1
Physician	2
Police officer	1
Railway agent	1
Retired	3
River and harbor inspector	1
Ship building	1
Steel manufacturer	1
Superintendent railway mail service	1
Superintendent stone quarry	1
Surgeon	1
Undertaker	1
Vessel owner	1
Wholesale confectioner	1
Total	92

(*f*). Ninety-three schools have contributed students to this institution, and of these schools the Houghton High School has sent the largest number of any single school, 19; Lake Linden High School, 14; the Michigan Agricultural College, 11; the Hancock High School, 10; and the University of Michigan, 9.

By some the claim has been put forward that the Mining School would diminish the number of pupils from the Upper Peninsula of Michigan that would attend the State University, but such a view does not seem to be well founded, for the effect of the Mining School upon the Upper Peninsula has been to stimulate a more general interest in education here, so that the University had double the number of students from this region in 1891–92 that she had in 1885–86, the year before this institution was founded. Again, the State University now has six accredited schools in the Upper Peninsula that send pupils to her on their diplomas, while, when the Mining School was organized, there was not a single such accredited school in the entire Upper Peninsula.

NUMBER OF STUDENTS ENTERING FROM EACH SCHOOL.

Adrian (Mich.) High School	1
Albion (Mich.) College	1
Alma (Mich.) College	3
Almont (Mich.) High School	1
Arcadia (Can.) College	1
Ashland Centre (Mich.) Public School	2
Augustana (Ill.) College	1
Battle Creek (Mich.) High School	1
Bay City (Mich.) High School	1
Beacon (Mich.) High School	2
Berlin (Germany) Mining School	1
Bessemer (Mich.) High School	2
Bonn (Germany) University	1
Calumet (Mich.) High School	5
Cambridge (England) University	1

Chicago (Ill.) High School	4
Chicago (Ill.) Manual Training School	1
Cincinnati (Ohio) High School	1
Cleveland (Ohio) High School	2
Clifton (Mich.) Public School	1
Coaticooke (Can.) Academy	1
Colorado State University	1
Constantine (Mich.) High School	1
Crystal Falls (Mich.) High School	1
Detroit (Mich.) Business University	1
Detroit (Mich.) High School	2
Detroit (Mich) Jesuit College	1
DeVeaux (N. Y.) College	1
Duluth (Minn.) High School	1
East Houghton (Mich.) Public School	3
Edinburgh (Scotland) Normal School	1
Elmira (N. Y.) Free Academy	1
Flint (Mich.) High School	1
Fond du Lac (Wis.) Cathedral School	1
Forest (Can.) High School	1
Franklin and Marshall College	1
Green Bay (Wis.) High School	1
Hancock (Mich.) High School	10
Hanover (Ind.) College	1
Howard University	1
Helena (Mont.) High School	1
Hillsdale (Mich.) College	2
Houghton (Mich.) High School	19
Hudson (Wis.) High School	1
Illinois State University	2
Ionia (Mich) High School	3
Iowa Military Academy	1
Iron Mountain (Mich.) High School	1
Ironwood (Mich.) High School	1
Ishpeming (Mich.) High School	1
Jacobsville (Mich.) Public School	1
Jefferson City (Mo.) High School	1
Kenyon Military Academy	1
Lake Linden (Mich.) High School	14
L'Anse (Mich.) High School	1

Lansing (Mich.) High School	1
Lawton (Mich.) High School	1
Lehigh University	1
Leslie (Mich.) Public School	1
Lima (Peru) School of Mines	1
Lucan (Can.) High School	1
Mariette (Ohio) College	1
Marquette (Mich.) High School	4
Michigan Agricultural College	11
Michigan Military Academy	5
Michigan State Normal School	4
Michigan State University	9
Milwaukee (Wis.) High School	1
Menominee (Mich.) High School	1
Mississippi College	1
Mobile (Ala.) Towl's Institute	1
Montana State College	1
Mount Hermon (Mass.) Academy	1
Newcastle (England), Durham College of Science	1
Newport (Md.) Public School	1
Norsköping (Sweden) High School	1
Northern Indiana Normal School	1
Notre Dame (Ind.) University	1
Ontonagon (Mich.) High School	2
Parlton (Eng.) High School	1
Port Huron (Mich.) High School	2
Portland (Ore.) High School	1
Quincy (Mich.) High School	1
River Edge (N. J.) High School	1
Rockland (Mich.) High School	4
Salt Lake City (Utah) Collegiate Institute	1
San Antonia (Tex.) Academy	1
Stanton (Mich) Union School	2
St. John's (Montreal, Can.) School	1
Tennessee State University	1
Toronto (Can.) University	2
United States Naval Academy	1
Wisconsin State University	6
Total	193

§ 3. COMPARATIVE GROWTH OF THE MINING SCHOOL.

In presenting a statement of the condition of the Michigan Mining School today it seems proper to compare its present size and growth with those of other schools giving instruction in mining engineering branches. In order to do this there has been compiled, as far as our means would permit, a list of schools of prominence that give instruction in the engineering branches.

In compiling the tables given here, serious difficulties have been met with, not only from the lack of a complete set of catalogues or registers of the different schools, but also more especially from the failure of many schools to designate in their catalogues the number of pupils in each course, and even when they do so designate them, it requires a long, laborious tabulation of each name marked by the various hieroglyphics—a fruitful source of error, and a labor the results of which show but little for the time it takes. Only two institutions of all those gone over do I remember as giving a convenient summary of the number of students in each course—Lehigh University and the University of Illinois. Lafayette College is a good illustration of the opposite extreme, as, without a single mark to designate them, she mixes in inextricable confusion her pupils pursuing Classical courses with those taking General Science, Civil, Mining and Electrical Engineering. Of schools that do this for their Scientific and Technical students there may be cited the Sheffield Scientific School, the Case School of Applied Science, the Colorado, South Dakota, and Missouri State Schools of Mines, and Vanderbilt University.

COURSES IN ENGINEERING, ETC.

Name of School.	1882 to 1883.	1884 to 1885.	1885 to 1886.	1886 to 1887.	1887 to 1888.	1888 to 1889.	1889 to 1890.	1890 to 1891.	1891 to 1892.	1892 to 1893.
Case School of Applied Science:										
Civil	....	....	....	....	....	....	....	108	....	167
Mining										
Mechanical										
Electrical										
and four other courses										
College of Montana:										
Civil	....	....	....	....	12	9	8	17	16	....
Mining										
Chemistry										
College of New Jersey:										
Civil	....	....	....	....	....	55	55	....	98	....
Electrical	....	....	....	....	....	....	10	....	48	....
Colorado State School of Mines:										
Civil	94	23	80	....	45	....	....	....	87	..
Mining						....	....	4		13
Electrical						....	....	....		..
Metallurgy						....	....	64		15
General						....	....	....		78
Cornell University:										
Civil	....	....	....	....	....	128	134	137	189	128
Mechanical	....	....	....	....	....	188	174	211	260	289
Electrical	....	.	....	....	....	126	172	214	250	257
Lafayette College:										
Mining	....	....	....	....	....	....	....	16	....	....
Lehigh University:										
Civil	....	....	....	....	148	....	123	116	....	154
Mining	....	....	....	....	56	....	68	52	....	64
Mechanical	....	....	....	....	91	....	66	63	....	106
Electrical	....	....	....	....	23	....	75	91	....	145
Michigan Mining School:										
Mining	..	....	....	23	29	40	35	65	78	92
Michigan State Agricultural College:										
Mechanical	....	....	....	....	....	93	118	127	....	....
Missouri School of Mines:										
Civil	....	....	....	..	....	....	....	80	83	....
Mining	....	....	....	....	....	....	12			
Mechanical	....	....	....	....	....	....	....			
Preparatory, etc.	..	....	....	....	....	....	57			
Ohio State University:										
Civil	....	....	..	....	....	....	33	36	59	....
Mining	..	....	....	....	....	....	17	21	36	....
Mechanical	....	....	....	....	....	....	21	11	18	....
Electrical	....	....	....	....	....	....	....	21	65	....
Purdue University:										
Civil	....	....	....	....	....	....	23	32	....	69
Mechanical	....	....	....	....	....	....	49	63	....	87
Electrical	....	....	....	....	....	....	37	73	....	123

COURSES IN ENGINEERING, ETC.—*Continued.*

Name of School.	1883 to 1884.	1884 to 1885.	1885 to 1886.	1886 to 1887.	1887 to 1888.	1888 to 1889.	1889 to 1890.	1890 to 1891.	1891 to 1892.	1892 to 1893.
Rensselaer Polytechnic:										
Civil	....	....	...	...	...	.....	174	189	185	....
Rose Polytechnic:										
Civil	....	3	4	....	...	28	20	23	20	....
Mechanical	....	61	64	...	....	112	122	133	139	....
Electrical	....	...	...	...	....	1	.....	.....	1	....
South Dakota State School of Mines:										
Civil	....	....	....	....	....	.....	....	...	19	....
Mining	....	....	...	...	....	.....	.....	2		
General	....	...	....	....	...	...	.....	...		
Union University:										
Civil	....	...	....	...	...	30	.....	35	...	....
University of Arizona:										
Mining	....	....	...	...	...	...	.....	.....	3	12
University of California:										
Civil	....	30	38	38	34	49	42	53	52	...
Mining	....	19	17	17	24	24	25	30	33	....
Mechanical	....	12	17	17	22	24	28	35	30	....
University of Illinois:										
Civil	....	...	....	...	....	.....	82	95	87	....
Mining	....	....	....	...	....	...	6	5	6	....
Mechanical	....	...	....	...	....	....	74	78	88	....
Electrical	....	....	...	....	....	....	.....	1	29	....
University of Kansas:										
Civil	...	....	...	....	...	15	18	17	32	....
Electrical	....	....	...	....	...	8	14	28	44	....
University of Minnesota:										
Civil	...	.	2	..	....	.....	19	30	23	....
Mining	...	..		..	...	.....	....	3	3	17
Mechanical	...	..		..	....	....	7	8	9	....
Electrical	...	..		..	....	....	6	29	35	....
University of Pennsylvania:										
Civil	....	....	51	....	...	82	.....	30	32	....
Mining	...	....	18	....	....	8	.....	6	5	....
Mechanical	....	..	84	....	....	20	.....	40	66	....
University of Utah:										
Mining	...	....	...	...	...	.....	.....	....	12	....
Vanderbilt University:										
Civil	...	....	....	....	....	.....	....	55		52
Mining	....	....	....	....	....	.....	.....		....	
Mechanical	...	....	....	....	....	.....	.....			
Washington University:										
Civil	....	....	....	....	....	.....	3	9	9	....
Mining	....	....	....	....	....	.....	13	15	11	....
Mechanical	....	....	....	....	....	.....	9	11	8	....
Electrical	....	....	....	....	....	.....	.....	.....	.....	....

Without entering upon invidious comparisons, the only criterion that at present can be taken with regard to the relative standing of schools in the various engineering courses, is the number of their students in those courses. Owing to the very different methods of grading students, this method of comparison is not always just, as some schools separate on entrance their students that take the different courses, while others do not make this distinction until the commencement of the second or third year; also the various difficulties enumerated previously may deprive some schools of their just and proper place in the schedule. Assuming as leading schools in engineering subjects all those that have over fifty pupils in any one of the engineering courses, the following tables give the relative standing of those schools. It is hoped that the officers of these schools mentioned and of other schools not named will send to the Director of the Mining School their past catalogues, and corrected lists showing the exact number of pupils there have been each year in each technical or engineering courses given in their respective schools. The statistics so far compiled indicate that, on the whole, institutions, like men, that devote themselves to some specialty, are more successful, than those that cover a wider field of instruction: also that in those schools that attempt to teach several branches of engineering there is a tendency to run more exclusively to one single course, while the other courses are more or less weakened.

CIVIL ENGINEERING.

Relative rank.	Name of the School.	Number of students.	Year of record.
1	Rensselaer Polytechnic Institute	185	'91–92
2	Lehigh University	154	'92–93
3	Cornell University	126	'92–93
4	University of Michigan	96	'91–92
5	College of New Jersey	93	'91–92
6	Columbia College School of Mines	92	'92–93
7	University of Illinois	87	'91–92
8	Massachusetts Institute of Technology	81	'91–92
9	Purdue University	69	'92–93
10	Ohio State University	59	'91–92
11	University of California	52	'91–92

MINING ENGINEERING.

Relative rank.	Name of the School.	Number of students.	Year of record.
1	Michigan Mining School	92	'92–93
2	Lehigh University	64	'92–93
3	Columbia College School of Mines	52	'92–93

MECHANICAL ENGINEERING.

Relative rank.	Name of the School.	Number of students.	Year of record.
1	Cornell University	289	'92–93
2	Stevens Institute of Technology	210	'91–92
3	Rose Polytechnic Institute	189	'91–92
4	Michigan Agricultural College	127	'90–91
5	Worcester Polytechnic Institute	119	'91–92
6	Lehigh University	105	'92–93
7	Massachusetts Institute of Technology	102	'91–92
8	University of Illinois	88	'91–92
9	Purdue University	87	'92–93
10	University of Michigan	78	'91–92
11	University of Pennsylvania	68	'91–92

ELECTRICAL ENGINEERING.

Relative rank.	Name of the School.	Number of students.	Year of record.
1	Cornell University	257	'92-93
2	Lehigh University	155	'92-93
3	Purdue University	122	'92-93
4	Massachusetts Institute of Technology	105	'91-92
5	Ohio State University	53	'91-92

As we have not here the data for the same year in every case, the relative position of some of the schools might be changed if their students for 1892-93 were known, and many other schools might be added if the statistics concerning them were at hand. So far as the schools that give instruction in Mining Engineering are concerned, our lists give all of them that are of any importance.

From these tables it can readily be seen that the Michigan Mining School stands in advance of every other school in the United States in the number of pupils in Mining Engineering, and has stood in advance for over two years, and is well up, even with most of the schools, in the number of students that they have in any other single engineering course. It may be thought that this increase of pupils in the Michigan Mining School is due to lower requirements for admission or easier work subsequently, but such does not appear to be the case, for the School increased its requirements and lengthened its course in 1889, and will do so again in September of this year. Such changes temporarily diminish the number of pupils, but the result in the end is greatly to increase their number.

(*a*). The following facts will serve to show that the grade of instruction and discipline is not below that of other schools that are considered to be of a high grade.

First—Students coming from other Mining Engineering schools to this one find that, as a rule, one year in other schools will only count them for about one-half year here.

Second—Out of thirty-four men that, less than three years ago, were in line to graduate this year, it is morally certain that not more than seven or nine will get through.

Third—Since September, 1890, there have been dismissed, suspended, requested to leave, or gotten rid of intentionally in some way, twenty-seven pupils, almost one-seventh of all the students that have ever been enrolled in the School from its commencement to the present time.

Fourth—In its required hours of work, its four terms a year, its short vacations, and its practical work, its present three years' course is the equivalent of the four years' course in many of the schools.

(*b*) Unless the present Legislature makes adequate provision for the increase of students in the School the number of the latter will have to be kept down, a result which it is hoped, will be effected by the lengthening of the course, and and by the greater stringency in the requirements for admission, such as age, etc. Otherwise a selective process, more rigid than at present in force will have to be adopted at the School, which will leave there only those most likely to profit by the course of instruction.

Experience has forced the Faculty to be more rigid in discipline with each succeeding year, and to insist that every student in the School shall attend strictly to the work required of him, and conduct himself in a proper manner, or else close his connection with the School. The rapid advance of the institution in numbers and the fact that no student has ever left it of his own motion to pursue a course in Mining Engineering elsewhere, until he had completed the course he had entered upon here, speaks strongly for the fact that the discipline and the course meet with the general approval of the students themselves.

For many reasons the Director would prefer to adopt the German university method, and allow every properly prepared student to enter and remain as long as he wishes, without any further restriction than that when he desired to graduate, he should pass a thorough examination in all the studies required for a degree. Some day this plan can be adopted, but it is the unanimous opinion of the Faculty, that, considering the average proficiency of the students now in the school, and the training they received before entering it, considering also the present condition of education in this country, the time is not ripe for this step in the Mining School, although the Director thinks that in some other engineering schools such a course could be adopted with advantage.

§ 4. GRADUATES.

Every effort has been made to make the instruction thorough and practical, so that the students, on graduation, should be fitted for their future work. This has been done to some extent, as very many men now in positions of trust and responsibility in the Michigan mining regions are either graduates or else have nearly completed their course here. All graduates are engaged in engineering or in allied professional work or studies, except two who have been debarred on account of ill health. The number of graduates thus far is twenty-two, but beside these the school should be credited with a number of others who have almost completed their course, and who are engaged in mining and allied work. Of these there are three that have only to present an acceptable thesis to receive their degrees, and six that have only a little work to do before the degree can be given. There are also many others that have taken special courses to adapt them to the special work they now do, and whose support is derived from the practice of the education they received in this institution.

Below is given a list of the graduates and their positions so far as now known; the effort is made to keep track of every man, to watch and take pride in his advance.

GRADUATES.

1888.

Name, Residence and Occupation.

HARRIS, JOHN LUTHER, S. B....................Quincy, Mich.
Mining Engineer, Quincy Mine.

LONGYEAR, EDMUND JOSEPH, S. B...............Merritt, Minn.
Superintendent of the J. M. Longyear explorations on the Mesabi Range.

PARNALL, SAMUEL ALEXANDER, S. B............Ishpeming, Mich.
Chief Mining Engineer, Cleveland and Iron Cliffs Mining Co.

PARNALL, WILLIAM EDWARD, S. B..... ....Ithaca, N. Y.
Electrical Engineering, Cornell University.

REID, WILLIAM JOSEPH, S B....................Boston, Mass.

SEAGER, JAMES BENJAMIN, S. B............... Hancock, Mich.
Civil and Mining Engineering, Lake Superior Redstone Co.

UREN, WILLIAM JOHN, S. B.................... Hancock, Mich.
Civil Engineer, Mineral Range and Hancock and Calumet Railroads, and County Surveyor, Houghton County.

1889.

CROZE, WALTER WILFRED JOSEPH, S. B.........Negaunee, Mich.
Chief Mining Engineer, Jackson Iron Company.

FARWELL, PAUL, S. B..........................Anaconda, Mont.
Assistant Chemist, Anaconda Mining Company.

*FESING, HERMAN WILLIAM, S. B ....Everett, Washington.
Civil and Mining Engineer.

*HAAS, JACOB, S. B...........................Everett, Wash.
Civil and Mining Engineer.

*See Graduates of 1890 for the Second Degree.

HOATSON, JOHN, S. B ....Butte City, Mont.
Mining Captain, Silver Bow Mine.

PRYOR, REGINALD CHAPPLE, S. B...............Houghton.
Civil and Mining Engineer.

1890.

DANIEL, JOSHUA, S. B.........................Great Falls, Mont.
Assayer, Boston and Montana Consolidated Copper and Silver Mining Company.

DRAKE, FRANK, S. B...........................Iron Mountain.
Chief Mining Engineer, Chapin Mining Company.

Fesing, Herman Wm., S. B., E. M. .... Everett, Wash.
Civil and Mining Engineer.

Haas, Jacob, S. B., E. M. .... Everett, Wash.
Civil and Mining Engineer.

Hodgson, William Adams, S. B. .... Houghton.

Sutton, Linton Beach, S. B. .... Palmer.
Mining Engineer and Chemist, Volunteer Mine.

Wakefield, Arthur Albert, S. B. .... Hurley, Wisconsin.
Civil and Mining Engineer.

1891.

Bossert, Otto Henry, E. M. .... Freiberg, Saxony.
Mining Engineering, Bergakademie.

Dengler, Theodore, E. M. .... Houghton.
Mining Engineer, Atlantic Mine.

Fink, Edward, E. M. .... Milwaukee, Wis.
Chemist and Metallurgist, Geo. W. Goetz & Company.

Lawton, Nathan Oliver, S. B. .... Ironwood.
Chief Mining Engineer, Penokee and Gogebic Development Company.

No pupils graduated in 1892, although several should have done so, as their course was entirely completed except the presentation of a satisfactory thesis.

The diminished number of graduates is not due to a decadence of the School, but to the fact that the class that entered in September, 1889, and that should have graduated in 1892, was very small because of the change in the course at the time of their entrance, the then unfurnished and unequipped state of the Mining School building, the increase in the requirements for entrance, etc. Further, with the lengthening of the course, the amount of work and the difficulty of graduating were increased.

(*a*) The following list gives the students, and the occupation of each, who nearly completed their course, and who by a little personal effort on their part should be enrolled as graduates, as in several cases only the thesis is wanting:

Close, Fred Bagley .... Hancock, Mich.
Civil and Mining Engineer.

Colwell, Alfred Bundy .... Negaunee, Mich.
Chemist and Assistant Mining Engineer, Queen-Buffalo Mine.

Dyer, Holmes Hayward........................Ishpeming, Mich.
Assistant Mining Engineer, Cleveland and Iron Cliffs Mining Company.

Graves, McDowell..............................Panama, C. A.
Assayer and General Engineer.

Hodgson, Joseph H.............................Stevens, Arkansas.
Hoop and Stave Manufacturer.

McDonald, Ronald H...........................Dollar Bay, Mich.
Chemist, Tamarack-Osceola Copper Manufacturing Company.

Meads, Alexander Parker......................Ontonagon, Mich.
Draughtsman, Diamond Match Company.

Palmer, Edward Vose..........................Negaunee, Mich.
Chief Mining Engineer, Queen-Buffalo Mine.

Scott, Dunbar Doolittle......................Ironwood, Mich.
Assistant Mining Engineer, Penokee and Gogebic Development Company.

§ 5. CHANGES IN THE COURSE OF INSTRUCTION AND REQUIREMENTS FOR ADMISSION.

In September, 1893, a number of changes will go into effect, the most important of which will be given below.

(*a*). The length of the course will be increased from three to four years, because it has been found that the present course is too difficult for the average student to cover in the specified time. This increase of time enables the same subjects to be given in a more elaborate and better form, as well as provides more fully for practical work, thus making the course better adapted to the needs of the mining engineer. The lengths respectively of the school-year and of the terms will remain the same as now, so also will the number of hours that the students will be employed each day remain the same, except that during the Freshman year they will be reduced to six hours, owing to the amount of outside work that is required of the students that year. The degree of Bachelor of Science will be again introduced and conferred upon all that complete the first three years of the course. This is done because it has been found that there is an extended demand for a three years' course in Mining Engineering, that will enable one to do most of the work that falls to the lot of the average engineer.

This demand is apparently due to the fact that the circumstances of many young men require that the latter should engage in their life work at as early a date as possible, while others have not the ability to complete the higher work demanded of those studying for the degree of Mining Engineer. These have been deemed sufficient reasons for arranging the course of study in such a manner that a young man may graduate in three years, if desirable, and yet may have covered sufficient ground to enable him to do the average work of a Mining Engineer well; in fact, the student who has taken the first three years in the Mining School has in reality done as much pertaining to his profession as is done in most courses of Mining Engineering, in the alloted four years, even if he has not done more.

The fourth year added to the course contains the higher professional studies and leads to the degree of Mining Engineer for those who have completed it and presented a satisfactory thesis. It is thought that this arrangement will remove many of the practical difficulties the School has been obliged to contend with in its course of instruction, and meet the needs of students better than the present course of three years.

(*b*). As a result of the past experience of the Mining School it has been thought advisable not to admit into the regular course any one under twenty years of age unless he shall have completed a regular course in some good high school or academy, while for special students the age has been raised to nineteen years. It has further been specified that for the regular course no student will be allowed to enter with any other conditions than Astronomy and Book-keeping; and also that all special students shall take sufficient work to occupy their time.

(*c*). The course of instruction would be greatly improved if it could offer various electives in, at least, the third and fourth years, to enable the students to specialize to a greater extent than is done at present in the regular course. This the School can not do at this time as the present work taxes the time and strength of the Faculty to the utmost, and no electives could well be afforded except by increasing the teaching force in the lines of the higher and more advanced work.

§ 6. NEEDS OF THE MINING SCHOOL.

The chief wants of the School in the line of additional teaching force are in the direction of the cheaper grades of work, i. e., assistants or instructors to help out the professors in their increased amount of work due to the larger number of pupils and the greater length of the course. In addition to the assistants now employed, one is needed in Chemistry, one in Physics and one in the practical work in Mining and Mine Surveying.

(*a*). At the present time Professor Haynes, in addition to his duties as professor of Mathematics and Physics, performs those of Secretary of the Faculty. This is too much for any one man to attend to in a proper manner. The remedy, if we consider the constantly increasing number of pupils. would appear to be reached by making him professor of Mthematics only, and dividing the Freshman class into two divisions for their mathematical recitations, thereby insuring better work. This with work in the Physical laboratory in the spring term would occupy all his time, and enable steps to be taken to put the department of Physics in accord with the other practical work in the School. The instructor of Physics in the Mining School ought to be some one who has had a thorough engineering training and thoroughly understands and appreciates those parts of Physics that bear upon and are of use in the other studies of the course.

The present Secretary of the Faculty can not give the personal attention to the records, so as to see that the regulations are carried out in each case where conditions are to be made up or various rules are to be enforced—matters that should always be promptly brought before the Faculty, unless the rules are to fall into contempt. Hence the secretaryship of the Faculty should be given into the hands of the clerk or a general secretary of the School, and the department of Physics, partly at least, placed in the charge of another instructor.

(*b*). As the present clerk and librarian closes his connection with the School this year, an opportunity is offered to readjust the duties of this position and unite them with others so as to make the effective work for the School very much greater, without any material increase in the expenses. The present clerk has done his work well and efficiently, and if he remained his duties could be so adjusted that the ends sought should be attained.

(*c*). The one great weakness at present in the School is in the work that centres about the Treasurer, Purchasing Agent, Clerk, Librarian, Requisitions, etc. The difficulties here have arisen on account of the business of the Mining School growing far more rapidly than was expected, and much faster than the provisions for taking care of it have grown. At the time the Treasurer was appointed, the business was small and could easily be handled, but with the rapid growth of that official's private business and the great increase of that in the School, the work in the Clerk's, Treasurer's and Purchasing Agent's departments has been in a deplorable condition. This has been going on for over two years, with repeated remonstrances on the Director's part, with promises and repeated promises made that it would be remedied, which have not yet been carried out, until the Director feels that he would be culpable unless he brought this directly to the attention of the Board, as the financial management of the School is not at all under the Director's control.

In making the statements that he does, the Director does not wish to be considered as reflecting upon the Clerk, Treasurer and Purchasing Agent, as he considers them honest and capable officials, but that the methods, arrangements, times of attending to payment of bills, etc., are not such as the present importance to the School of the prompt and rapid handling of its business demands.

The chief complaints made are the delays in the payment of bills and the adjustment of accounts, and delay in orders.

It is common to have bills run three, six, and twelve months or longer, after they are due and after they have been properly avouched for by the Director for payment. In order to save the funds of the School many of its purchases are made at reduced rates, on condition of prompt payment, conditions in the fulfillment of which so much difficulty has been found that the credit of the School has been seriously impaired, and it is now cut off from purchasing at some of the best houses, while it appears the discounts given have been materially curtailed. This state of affairs leads to the sending of repeated drafts on the School, drafts on the Director, repeated dunning letters to him and even threatened suits, although he has nothing whatever to do with the payment of any bills for the School. In order to try to remedy this state of affairs the Director has ordered the Clerk to freely give his time to the Treasurer, although the former official was greatly needed at the School, and he has thus been unable to attend to his necessary dutes on account of from half to two-thirds of his time being taken up in attending to accounts, requisitions, bills, etc. Very much of the time of the Director and of the instructors is taken up in attending to dunning letters and to other business that does not properly belong to them, and this seriously interferes with their attention to the duties that properly devolve upon them, and causes the School to suffer thereby.

The time taken from the various officers of the School, the derangement of its business, its increased cost on its purchases, and the delays in its work produced by neglect of sending orders at the proper time, the Director estimates as causing a direct loss to the School of between one and two thousand dollars each year.

The condition of affairs relating to the general duties of the purchasing agent and the general method of making purchases and obtaining requisitions are hardly more satisfactery than the previously mentioned subjects. The purchasing agent at present claims (and accepted the position on that claim only) that he should be looked upon simply as a clerk without any responsibility in the matter beyond sending out the orders, after proper requisitions have been put into his hands by the School officers. The agent certainly should look carefully into all questions of purchases, assume a certain amount of official responsibility for them, and see that they are made with proper restrictions in the best and cheapest market. Care of this kind would result in sufficient saving for the School to nearly if not entirely pay his salary. Further, the purchasing agent ought to be someone attached wholly to the School, and not dependent at all for his livelihood on local patronage, but only upon the question of how well and faithfully he does his duty by the School, and how valuable and efficient an officer he can become.

(*d.*) The present method of getting out requisitions is cumbersome, wastes valuable time and serves no useful purpose, but allows everyone to escape from direct responsibility. The method was perhaps good enough in the earlier days of the School when the business was small, but as it is now, when the business is large and constantly increasing, and the members of the Executive Committee widely scattered and frequently absent, it leads to most vexatious delays, in endeavoring to get access to the members of the Executive Committee, who are busy men and burdened with other and far more pressing cares of an entirely different nature from those pertaining to the School.

The Director has not seen any saving or advantage obtained by the present system, but on the other hand has seen much loss, and friction.

The system adopted in the State University of selecting a few officers, whose offices are contiguous and who have a personal and direct knowledge of the needs of the institution, and making them directly responsible to the Board for the requisitions and purchases, would be an improvement upon the system now in force here.

(*e.*) The Director in the discharge of his duties has endeavored to ascertain in what way he could in the future do the School the most good, and finds that it is apparently in the way of giving more instruction, rather than in giving more time to the minor duties of his office. In response to this conviction he desires to give more and better instruction to the pupils, although he has made many improvements in that direction in the past year. In order to accomplish this better in the future he needs relief from certain portions of the work he now does, i. e., the detailed preparation of the catalogues, which he has heretofore done, the preparation of statistics, various articles, etc., demanded for the Legislature, for his reports, and for various other purposes.

The Director does not wish to escape from attending to the general direction of his work, but thinks that when he has laid out the ground, he ought to have assistance of sufficient intelligence so that the details can be properly attended to by another and leave him to give his time to work that others cannot do, and which is really of more advantage to the institution. He considers that his employment in doing the work that much cheaper help can do, as soon as the needs are pointed out, is not economical for the institution.

(*f*). The remedies for the various evils, the Director thinks, lie in the following steps: To unite the salaries of the Treasurer, Purchasing Agent, Clerk and Librarian, and appoint one or two competent persons who shall have their offices in the School building, as is customary and where they should be. One, at least, of these parties, should have a good knowledge of school work and literary and business ability, and should serve as secretary of the School and Faculty, be charged with the records of the School, see to it that the cases of all delinquent or conditioned students are brought before the Faculty, and attend to various duties that would properly devolve upon him. One competent man, if given good clerical help, could attend to all the duties here enumerated, if the business were consolidated and the present onerous method of obtaining requisitions changed to the more rapid and convenient system in vogue at the State University.

(*g*). Experience shows, that for the subordinate positions better results are obtained, on the whole, by employing in a school the graduates of that school than by engaging the inexperienced graduates of other institutions. As a rule, the latter approach their work with the feeling that the school from which they graduated is the only one which properly does its work, and rarely do they realize or take into consideration the different conditions or situation of the School to which they are called.

Hardly ever do they show, at first, any ability to understand their changed surroundings and endeavor to accomplish that for which they are employed, but rather think that their duty consists in endeavoring to make their present situation conform to the peculiar conditions of their *alma mater*. In time they learn what they should, but the experiment of teaching them is a costly one for the institution that has to depend upon such assistance.

By taking the recent graduates of any school for assistants in that institution, then this feeling toward their mother institution renders them very valuable, as they have been trained in the desired methods and work, which training generally has to be given to the graduates of any other school during the time they are serving as assistants.

(*h*). Some kind of a partial or entire endowment is greatly needed for the Mining School, to remove it from its entire dependence upon legislative aid, and also from the peculiar situation it finds itself in every two years on January first, without a single dollar to pay its running expenses, but must depend upon its faith or hope of what a Legislature not then convened will do.

The highest standard never will and never can be obtained in a school situated so as to be at the entire mercy of the political winds.

A productive endowment of one million dollars would enable it to do its legitimate work as a mining school, provide its necessary buildings and equipment in time, and in time if wisely managed stand in the van for thorough, high and hard work.

(*i*). The Director again calls attention to the need of a gymnasium, etc., for the use of the students. They need it not only for their physical but also for their moral health. Where mental work is so severe as it is at the Mining School, relaxation of some kind becomes absolutely necessary, or the mind or health will break. If pure and healthful relaxation is provided, then much is gained; for if no other place can be found the student will surely seek the bar-room, saloon and gambling hall. In no way can so much be gained for the right, it seems to the Director, as in provision made for enobling, healthful and attractive recreation for the young student.

§ 7. APPROPRIATIONS.

On account of the increase in the number of students and of the lengthening of the course of instruction, it has been found necessary that an additional building should be erected upon the grounds belonging to the Mining School. This building it is proposed to use for the Machine Shops, Testing and Electrical Laboratories, the Mining Engineering Laboratory, the Drawing Room, and for the boilers, engines and fuel.

In the present building there are but two recitation rooms large enough to accommodate the present entering class, and no room large enough to have all the students assemble in for any purpose whatsoever. Part of the laboratories also are too small to accommodate classes of the size that the school now has. Every available foot of room is occupied, and the limit of expansion of the number of students is nearly reached, unless further accommodations can be given. It is proposed to do this by erecting the building specified: to fit up the present Machine Shops and Assay Laboratory for a Physical Laboratory and for recitation rooms; to fit up the present Drawing Room for a Library, using the smaller recitation rooms adjacent for offices, reading rooms, etc.; to equip the present Physical Laboratory as a general lecture room; the present Chemical Lecture Room for laboratories for advanced work, and to make such other changes as may be necessary for the accommodation of the students.

A Metallurgical Laboratory is very much needed, as stated in former reports; but it has been decided, on account of more pressing demands, to leave this to subsequent years. I would, however, earnestly commend to your attention the Report of the Professor of Metallurgy.

The amount of money needed for the Engineering Building will be $30,000, with $12,500 to cover the equipment, expenses of moving, and for repairs and alterations needed in the present building.

The need of the new building is well shown in the report of the Professor of Mechanical Engineering, and I would refer you to that in order to avoid repetition.

A very pressing need has been found to be a residence for the chief executive officer on the school grounds, as it is impossible to find any building suitable for that purpose nearer than a mile from the grounds. There is no institution in the country of standing, no mine or business enterprise of prominence, no church that does not provide something for its chief executive officer. It is impossible for any one to obtain the comforts of home, retain his health, or do his work as he should, with such a constant pressure of care and work as the Director has, when a boarding house is all that can be obtained in the vicinity of the School at the present time. This prevents his attending to many of the duties that naturally devolve upon him, and seriously interferes with his work and health.

On account of the greatly increased number of students that take the work in the Physical Laboratory, an increase in its equipment is essential, if the work is to be properly done, and the sum of $4,000 is asked for this.

The estimated current expenses of the Physical and Mathematical Departments are estimated at $1,000 for the two years, or the same as in past years, although the number of students has greatly increased.

In order to keep up the Library to any useful point, the valuable periodicals need to be bound and the important new works added as issued. There is no attempt made to make the Library anything except the special technical one that the needs of the institution demand. For these purposes and to keep up the Reading Room, the smallest sum that can be got along with is $5,000 for the two years, although that is less than the expenditures of previous years, and much more is needed. Attention is called to the report of the Librarian.

In the Chemical Department additional permanent equipment to the amount of $500.00 is required, while the running expenses for supplies, repairs of balances, etc., demand some $3,450.00, or an amount less than the estimates for two years ago.

In the ore dressing work or stamp mill, additional apparatus, lecture specimens, and drawings are asked for to the amount of $1,200.00. This is for permanent equipment, while for the two years $2,400.00 will be needed for the current expenses for fuel, ores, freight on the same, mercury and other chemicals, and for repairs and additions to the mill. This is an increase, due to the increased amount of work now done in that department, as the estimate includes the running expenses for the metallurgy.

In the Metallurgical Department the sum of $600.00 is now needed for lecture specimens to be added to the permanent equipment.

In Assaying the current expenses are estimated at $800.00 for the two years to supply the necessary fuel, ores, crucible reagents, repairs to furnaces, etc., or a lower estimate than formerly.

The Photographic Laboratory needs additional permanent equipment to the amount of $400.00, and $500.00 for the two years for current expenses. This Laboratory has become essential to the work of the School in supplying the illustrations, diagrams, etc., that are needed in the lectures, particularly those given in the Departments of Metallurgy, Assaying, Ore Dressing and Mining, and therefore needs an appropriation larger than before.

Drawing, Mechanical and Electrical Engineering, need for running expenses at least $1,200.00 for the next two years.

The Department of Mining Engineering needs $75.00 for additional permanent equipment, and $1,280.00 for its operating expenses during the two years.

In Petrography additional permanent equipment to the amount of $380.00 is needed, while for running expenses $120.00 are required for the two years.

The Mineralogical Laboratory asks for but $175.00 for the two years, a sum very much less than previously required.

For the insurance, especially if the new building is erected, at least $3,500.00 should be obtained for the next two years, as neither the State nor the Board of Control can afford to allow the property of the State to remain uninsured. There is already collected in the buildings of the present institution, with the buildings themselves, property amounting to $160,000.00. A fireproof safe is also very greatly needed to preserve our records and other important and valuable property in case of fire.

The estimate for freight, drayage, catalogue, postage, printing, etc., is $2,000.00, an amount much less than we previously asked for. The care of the grounds and the water supply it has been found necessary to increase. $1,000.00 are asked for, for the next two years.

In order to supply unforeseen contingencies and also to provide for numerous subsidiaries which cannot be estimated, the sum of $5,000.00 for the two years is asked. For the general contingent expenses and to meet unexpected demands upon the School such a fund is always allowed every institution, as no estimate can cover everything or can always provide for the contingencies of two years.

The estimate for the fuel and lights has been increased by $300.00 on account of the necessary additional heat and light if the new building is erected.

The present position of the boilers is not only a menace to the property of the State, which, as previously stated, amounts to some $160,000.00, that can readily be destroyed by fire, but it is also a menace to the lives of every teacher and student in the building, as long as the boilers remain there. Every effort is made to guard against explosion or fire, but the dangers are such that they cannot be provided against in all cases. The Assay Laboratory is also another serious danger, especially with the present necessity of using the Laboratory as a carpenter shop during the winter season. This greatly increases the danger of fire. It is desirable to have the fire risk reduced to a minimum, and if the boilers should explode, that they should be in a position to do no harm excepting to their own shed, and not to the other buildings of the School and to the lives of its students and employees.

(*a.*) The salaries for the present officers remain on the same scale at present without any increase, with the exception of some small changes in the wages of the minor or subordinate afficers, who are entitled through their services to some additional compensation and who are unwilling to remain without it.

Some additional assistance is asked in order to accommodate the increased number of students, and the increased business of the School. This assistance however, is intended to be in the form of laboratory instructors and assistants, etc., and is only asked because it is absolutely needed, owing to the increase in the number of students.

For the salaries, then, for the two years the sum of $46,060.00 is asked.

As soon as practicable the salaries of the professors ought to be raised, as they are lower here according to the expenses and to absence of almost everything that makes a teacher's life endurable, except hard work. This is one reason why the Director has labored so hard to see that each one should have in his department the means of doing his work well, for if this were denied, there would be nothing left to bind any teacher to his situation. It is the good men that, as a rule, are driven away by small salaries and uncongenial surroundings. Already one professor has announced his intention to leave, and, unless the warnings given in the Report of the

Director for 1890, concerning the relations of the Board, Director and professors, are heeded better in the future than in the past, serious trouble for the School is liable to ensue, as nothing will destroy all the interest of a man, or drive him away so surely, as constant and unwarranted interference in his legitimate work.

The reason that part of the running expenses have been diminished is owing to the fact, that with increased equipment, it is not necessary to ask for as much as when it was necessary to provide for additional equipment, which has always been done, so far as practicable, with whatever could be saved from the other expenses. It is more economical per capita to provide for a large number of students than for a small number, since the initial and running expenses are about the same, while the additional help to the teaching force, and other expenses are mainly in the form of additional buildings and in the cheaper grade of teaching, that is, more assistants.

(*b*). The following quotation taken from one of the leading engineering journals in the United States, gives some ideas that are appropriate to the conditions in this institution:

"Technical education is the most expensive kind of school training. Not only must the instruction be mostly imparted by specialists, who command (or ought to command) high salaries, but the plant required is very expensive, and the material consumed considerable. It is for this reason that so many of the schools purporting to give courses of instruction in engineering, fail utterly to attain to respectable standing as technical schools. They place the technical courses on the same basis as their literary courses, put them in charge of the traditional college faculty, where the same professor might in time teach mathematics, Greek, Latin, physics, or some branch of science, or one or more of the modern languages, and with no other facilities than text books and recitation benches, announce in their catalogues complete courses in "Civil and Mechanical Engineering." This is not so much the fault of the teachers as of the president, who is perhaps a superanuated minister, and of his board of trustees, who perhaps are all good church deacons and bank presidents. Their only idea of a school of any kind is the hearing of lessons heard from books, and why not lessons in engineering as well as in anything else. The greatest impediment now to better educational facilities in even the best schools (with a few exceptions) is the failure on the part of the officers and boards of directors to appreciate the necessity for all these costly appliances. They are often looked upon as the toys or vanities of the professor rather than as essential instruments of education for the boy. * * *

"The professors in the best schools are also high-priced men; and grow more so with time. Men properly qualified by knowledge and experience to teach young engineers, can command good incomes in the practice of their profession.

"The schools are finding great and increasing difficulty in keeping such men as they have, and it is almost impossible to find suitable new ones to replace those who drop out. The only remedy is higher salaries. A board of trustees, however, dislikes to pay a professor of engineering more than other members of the faculty receive holding similar responsible positions, and as a result these places are often filled by young graduates with no practical experience, very much to the detriment of the school.

"To pay all these heavy expenses, either the tuition must be very large or the endowments very generous. * * * * In most of the best engineering schools the annual tuition is $150.00 and upwards, although some of the very best have free, or nearly free, tuition.

"But even with these large fees, the schools are not self-supporting unless the number of students is very great. In one school reporting these facts, the annual expenditure for instruction and facilities is given as $31,000.00, while the whole number of engineering students in 1890–91 was but sixty-two. The annual tuition is but $150.00, but this is remitted in many instances, so that counting out these excepted ones and those who hold scholarships, there are not more than fifty who pay the full amount, producing an income of $7,500.00, or only about one-fourth the cost of instruction. That is to say, for every $150.00 the average student pays, some one else pays $450.00 in order that he may be taught."—*Engineering News, Vol. XXVIII, 1892, Page 546.*

(*c*). *Appropriations asked for the Michigan Mining School.*
Current expenses two years.

Physical laboratory	$1000 00
Chemical laboratories	3450 00
Assaying	800 00
Ore dressing and stamp mill	2400 00
Photographic department	500 00
Drawing Mechanical engineering Electrical engineering	1200 00
Mining engineering and surveying	1280 00
Mineralogical laboratory	175 00
Petrographical laboratory	120 00
Geological laboratory and field work	1000 00
Library, reading room, binding, etc	5000 00
Fuel and lights	4800 00
Insurance	3500 00
Repairs	1000 00
Freight, express, drayage, printing, catalogue, telephone, reports, postage, etc	2000 00
Care of grounds, water supply, etc	1000 00
Contingent expenses	5000 00
Salaries, labor, etc	46060 00
Total	$79785 00
Estimate for 1891–1892	73400 00
Increase asked for	$6385 00

Pupils, 1¼ times as many as at this time in 1891.

Appropriations asked for the Michigan Mining School.
Building and equipment.

Engineering building	$30000 00
Equipment, moving and altering old building	11500 00
Director's residence	6000 00
Equipment of physical laboratory	4000 00
Chemical laboratory	500 00
Ore dressing and stamp mill	1200 00
Metallurgical department	600 00
Photographic laboratory	400 00
Mining engineering	75 00
Petrographical laboratory	380 00
Fireproof safe	500 00
Total	$55155 00

§ 8. INVENTORY OF PROPERTY OF THE MICHIGAN MINING SCHOOL.

Assay Laboratory.

Ores, bins, cases, etc.	$140 00	
Furnaces	700 00	
Assay apparatus	355 00	
Assay supplies	485 00	
Assay balances	430 00	
		$2110 00

Metallurgy.

Drawings and photographs	$200 00	
Pyrometer	50 00	
Collections	75 00	
Furnace	700 00	
		1025 00

Stamp Mill.

Stamps, copper plates, extra shoes and dies,	$375 00	
Blake crusher and extra toggles	300 00	
Crushing rolls	85 00	
Sample grinder	50 00	
Amalgamating pan	170 00	
Carried forward		$3135 00

Brought forward		$3135 00
Settler	$169 00	
Pipes and framework of above	40 00	
Frue Vanner	300 00	
Spitzkasten	60 00	
Two leaching tanks	35 00	
Two jigs	290 00	
Calumet separator	75 00	
Two centrifugal pumps	150 00	
Shafting and pulleys	275 00	
Belting	150 00	
Engine and boiler	900 00	
Tools	35 00	
Suction pipe	25 00	
Drawings	55 00	
		3439 00

Photographic Laboratory.

Furnishings and fittings	$180 00	
Apparatus	296 00	
		476 00

Department of Mechanical Engineering.

Machine Shop:—		
Shaper	$275 00	
Vises	140 00	
Forges	33 00	
Engine lathe	575 00	
Milling machine and attachments	580 00	
Pulleys, shafting, etc	75 00	
Planer and attachments	620 00	
Storage cells	36 00	
Taps	8 00	
Belts and packing	235 00	
Gauge disks	42 00	
Metals on hand	95 00	
Wires, lamps, fittings	100 00	
Miscellaneous tools	710 00	
Emery grinders	112 00	
Carried forward		$7050 00

Brought forward		$7050 00
Machine Shop—continued:		
Cutter grinder	$62 00	
Buffer	50 00	
Oilers, etc.	15 00	
Large drill	300 00	
Small drill	81 00	
Cases and shelves	110 00	
Benches	75 00	
Posts and post hangers	47 00	
Boiler pump	25 00	
Pyrometer	23 00	
Plumbing tools	80 00	
Plumbing supplies	75 00	
Inspirator	10 00	
Thermometers	32 00	
Valves	15 00	
Injector	9 00	
		4645 00
Pattern Shop:		
Motor and armature	$151 00	
Band saw	102 00	
Two pattern lathes	114 00	
Scroll saw	54 00	
Edison dynamo	428 00	
Cables, etc.	116 00	
Grindstone	21 00	
Pulleys, hangers and belting	150 00	
Circular saws	40 00	
Tools, oilers, vises	150 00	
Lumber on hand	80 00	
Benches and shelving	200 00	
Posts and post hangers	47 00	
Pump and gauges	130 00	
Engine	350 00	
		2128 00
Testing Department:		
Riehle tension machine	$1150 00	
Cement tester	179 00	
Carried forward		$13823

Brought forward		$13823 00
Testing Department—continued.		
Oil tester	$125 00	
Tabor indicator and attachments	180 00	
Crosby indicator and attachments	95 00	
Tachometer	60 00	
Torsion testing machine	415 00	
Planimeters, calipers, etc.	75 00	
Scales	50 00	
Micrometer	82 00	
		2361 00
Drawing Room:		
Drawing tables	$1098 00	
Blue-printing apparatus	175 00	
Colors, brushes, etc.	35 00	
		1208 00
Office of Mechanical Engineering:		
Books and sundries	$48 00	
Furnishings	255 00	
Supplies	38 00	
Cable samples	35 00	
Sectional injectors	120 00	
		496 00
Recitation Room:		
Desk and platform	$35 00	
Students' chairs	62 00	
		97 00

Petrographical Laboratory.

Petrographical apparatus	4835 00	
Crystallographic apparatus	411 00	
Optical apparatus	415 00	
Collections	610 00	
Tables and cases	291 00	
		6562 00

Laboratory of Economic Geology.

Cases and tables	$328 00	
		328 00
Carried forward		$24965 00

Brought forward		$84965 00

Geological Laboratory.

Invertebrate collection	$210 00	
Paleontological collection	660 00	
Geological collection	191 00	
Archæological collections	500 00	
Lithological collections	975 00	
Geological models	50 00	
Paleontological charts	150 00	
Cases	396 00	
Desk, tables, etc	95 00	
		3227 00

Mineralogical Laboratory

Blackboards, tables, etc	$151 00	
Cases	423 00	
Emerson collection	200 00	
Blowpipe collection	75 00	
Mineralogical collections	5718 00	
Exhibition collections	275 00	
Mineral trays	305 00	
Crystal models	1150 00	
Fume chamber	40 00	
		8332 00

Goniometer Laboratory.

Case and tables	$26 00	
		26 00

Director's Office.

Desk and furnishings	$150 00	
Cases, etc	135 00	
Tables	27 00	
Letter file	70 00	
		00

Lower Hall and Coat Rooms.

Cases and furnishings	$82 00	
		82 00
Carried forward		$97014 00

Brought forward		$37014 00

Library.

Books, maps, pamphlets and periodicals	$17051 00	
Cases and furnishings of reading room	260 00	
Cases of Library	248 00	
Desk and furnishings	45 00	
Typewriters	180 00	
		17784 00

Supplies.

Stationery	$25 00	
Postage	8 00	
Catalogues	5 00	
Reports	10 00	
		48 00

Mining Engineering Department.

9 Transits	$2858 05	
31 Levels	1016 45	
21 Steel tapes	228 00	
11 Compasses	572 00	
22 Chains	109 75	
Poles and rods	338 50	
Plummets and bobs	102 50	
Plane table	270 00	
Cases	290 00	
Office desks and fittings	110 00	
Drawing instruments and materials	136 00	
Planimeter and protractors	83 00	
Terrestrial globe, three feet diameter	130 00	
Miscellaneous apparatus	98 75	
56 students' chairs	140 00	
		6478 00

Physical Laboratory.

Physical apparatus	$4410 00	
Tables and cases	625 00	
		5035 00
Carried forward		$66359 00

Brought forward		$65859 00

Mathematical Recitation Room.

Chairs and desks	$175 00	
		175 00

Chemical Department.

Balance Room.		
Balances	$1014 00	
Furnishings	35 00	
		1049 00
Professor's Room:		
Mortars	$55 00	
Drying ovens	54 00	
Desks and furnishings	105 00	
Miscellaneous apparatus	15 00	
Fume chamber	80 00	
Glassware	28 00	
Air pump	8 00	
Collection of rare elements	150 00	
		495 00
Chemical Lecture Room:		
Tables and chairs	$285 00	
Air pumps	38 00	
		323 00
Quantitative Laboratory:		
Laboratory tables, complete	$1080 00	
Fume chambers	215 00	
Glassware	80 00	
Burners and furnaces	80 00	
Mortars	18 00	
Hydrometers	8 00	
Thermometers	47 00	
Miscellaneous apparatus	56 00	
		1584 00
Qualitative Laboratory:		
Laboratory tables, complete	$1400 00	
Fume chambers	200 00	
Special apparatus	350 00	
Case	65 00	
		2015 00
Carried forward		$72000 00

Brought forward		$72000 00
Chemical Supply Room:		
Shelving, cases and fittings	$168 00	
Scales and weights	13 00	
Glassware	565 00	
Porcelain ware	256 00	
Platinum ware	1602 00	
Apparatus for distilling water	10 00	
Silver crucibles	12 00	
Gooch crucibles	45 00	
Nachet microscope	60 00	
Dessicators	36 00	
Bellows	24 00	
Batteries	35 00	
Gas holders (copper)	60 00	
Blowpipes	50 00	
Bunsen burners	80 00	
Chemical apparatus	345 00	
Chemicals	635 00	
Miscellaneous supplies	274 00	
		4270 00

Attic.

Text books	$20 00	
Gas fixtures and lamps	40 00	
Soap, towelling and matches	30 00	
Table	3 00	
Miscellaneous stores	43 00	
		136 00

General Items.

Chairs	$295 00	
Blackboards	285 00	
Curtains	80 00	
400 feet 2-inch hose	280 00	
300 feet garden hose	90 00	
Storm sheds	55 00	
		1030 00
Carried forward		$77436 00

Brought forward		$77436 00

Land and Buildings.

Land	$5000 00	
Water supply, tank, grading, etc	12824 85	
School building	64624 21	
Stamp mill building	1783 35	
Metallurgical furnace building	291 00	
Building for coal and stores	475 60	
Heating apparatus	4450 60	
Lighting apparatus	3321 89	
		92721 00
Total of inventory		$170157 00

INSTRUCTION UNDER THE CHARGE OF THE DIRECTOR.

During the past summer many additions were made to the collections in Mineralogy which were thus put in excellent condition, and it is hoped that they will not require any specially large expenditures for a number of years. Of course the ordinary wear and tear due to the use of collections by a large class every year need to be made good, while certain changes have to be made from year to year to meet the commercial changes in the subject, i. e., certain minerals become very rare, or of but little importance, while others that were formerly either rare or nearly valueless are found abundantly or else become of great economic importance. In an institution professing to give instruction relating to the mineral wealth of the world, pace must be kept with the various commercial changes in order that the graduates may be prepared to engage in their future work more understandingly.

Beside the additions made to the collections, both the Lecture and the Practice collections, have been rearranged, and the Lecture collection relabeled and renumbered during the past summer, to correspond with the sixth edition of Dana's System of Mineralogy published at that time. I have also entirely rewritten and revised my lectures on Mineralogy to correspond, a labor of no small proportions.

In the year 1891–92 I gave the lectures in Mineralogy to the classes of the first and second years, while during the year 1892–93 I have given these lectures to the first year class and others, in all numbering forty-two men. It has to be remembered that the classes in this institution are far larger in these special subjects than are those in the same subjects in such leading institutions as Harvard, Johns Hopkins or Michigan Universities.

The Lithological collection has been numbered and labeled and lectures were given in Lithology in 1891–92, to the students of the first year and to various special and graduate students. In 1892–93 instruction and lectures upon Physical Geology and Lithology have been given to the graduating class and others, numbering some twenty men.

As usual the laboratorary work has been attended to by the instructors and assistants, Messrs. Hubbard, Patton, Seaman and Lane, who have also attended mainly to the work upon the collections. I am, however, indebted especially to Mr. Seaman for his labor, care and skill in this direction.

Dr. Patton gave the lectures upon Crystallography in 1892–93, spent much time upon the crystal collection, and has had the principal charge of the laboratory work in Mineralogy this year, as last.

Dr. Lane has given the instruction in Petrography, Paleontology and Stratigraphical Geology, both years, and in 1891–92 that in Economic Geology. Dr. Patton assisted him in the laboratory work in Petrograhy.

The design of the instruction under the Director's charge is to give that training, knowledge and skill that all men who are engaged in mining ore and other useful mineral deposits ought to have. In Mineralogy the design is not only to have the student familiar with all the minerals he will be likely to meet in his life work, but also to train him in methods of observation and research that he will afterwards need. This course is the foundation for all the subsequent work in Geology, etc. In Petrography the object is to familiarize the student with the use of the microscope, an instrument that every engineer ought to be familiar with; it is also intended to give him some idea of the optical properties of minerals, and to teach him the various alterations and changes that have taken place in the minerals and rocks—a knowledge that he must have, if he is to understand his subsequent work in Lithology and Physical and Economic Geology, as almost every question relating to ore deposits is intimately dependent upon the facts of Petrography.

It is not intended to make the undergraduates petrographers—a work that would require all their time for three years at the very least—but to give them just that kind of knowledge and skill which they need for their subsequent work.

In Lithology it is intended to give the student a practical working knowledge of the rocks of the globe, their variations and alterations, and such other knowledge concerning them as he needs in his subsequent work. Most of the notes in Lithology have been mimeographed and these are readily accessible to the students. In Paleontology and Structural Geology it is not intended to go very far, only to give that instruction in the elements which an engineer needs for his future work, and thus omit much that is given in colleges as a matter of general education. In Physical Geology it is intended to give a thorough course, on account of its bearings and use in the study of Economic Geology and in the future work of the engineer. The work in Economic Geology is intended to be the chief work of the departments under the Director's charge, and all the preceding instruction is subordinate to and leads to it. It is hoped to make the instruction in this subject philosophical and practical and thus useful to the engineer. This course will have to be devoloped by lectures and it will be the work of years to make it complete, as no satisfactory text-book upon the subject can be procured. The great difficulty with most teaching in Economic Geology is that it embodies a great mass of undigested facts that have no scientific nor philosophical principles that the student can make use of hereafter. (*b*). As stated before, the Director finds that apparently his usefulness to the School can be increased if he can give more time to the development of the instruction in his department, as experience has shown well that he can not have the teaching or laboratory work, as a rule, given as he wishes it, or as he thinks the needs of this institution demand, unless the assistants or instructors have been trained under him or at least have entered into the spirit of his methods. In order to accomplish the desired development of his instruction, it is necessary for him to be relieved from certain of the clerical parts of his present work—work that can be much more economically performed by some one else, whose time is not occupied by professional duties, and it ought to be as well done after it has been laid out by the Director. Dr. Hubbard has rendered most able and valuable assistance in this direction during such time as he could be spared from his other duties, but it is not probable that those duties will enable him to be used for this purpose much longer. Much information is sought by the Legislature and the general public concerning the School and its surroundings and hereafter this ought to be furnished by the Clerk or Secretary under the supervision of the Director. The Director has done what he has been able to do in the line of publication as an aid to the School, but with a clerk that is familiar with publication work and educational work much more ought to be done for the institution in the future.

(*c*). The following articles and papers by him have been published or are in process of publication, since the Director became connected with the Mining School, in addition to the numerous private reports and papers that have been prepared for the Board, Legislature and others.

1887.

The Volcanic Theory of Ore Formation.
Engineering and Mining Journal, 1887, XLIV., 892.

1888.

The Work of Charles E. Wright, late State Geologist.
The Marquette Mining Journal, March 24, 1888.

First and Second Annual Catalogues of the Officers and Students of the Michigan Mining School, Houghton, Michigan, 1886–1888. 52 pages.

1889.

Report of the State Geologist, 1888–1889. 6 pages.

The Iron Ore of Cumberland Mountain, Rhode Island.
The Bulletin of the Iron and Steel Association, 1889, XXIII., 314.

Third Annual Catalogue of the Officers and Students of the Michigan Mining School, Houghton, Michigan, 1888–1889. 55 pages.

Our Marble Monuments.
Portage Lake Gazette, 1889, December 12.

1890.

A Sketch of the Geology of the Marquette and Keweenawan Districts.
In "Along the South Shore of Lake Superior," by Julian Ralph, New York. 1890. 20 pages.

Report of the State Geologist for 1889–1890. Six pages.

Mineralogical Description of the Llana del Inca and the Dona Inez Meteorites.
Proceedings of Rochester Academy of Science, 1890. I., 95–98.

Catalogue of the Michigan Mining School, Houghton, Michigan, 1889–1890. 72 pages.

1891.

A Sketch of the Geology of the Marquette and Keweenawan Districts. Second Edition, revised. 26 pages.

In "Along the Bowstring, or South Shore of Lake Superior," by Julian Ralph. New York. 1891.

Report of the Director and Treasurer of the Michigan Mining School, Houghton Michigan, 1886–1890. 148 pages.

Report of the State Geologist for 1890–1891. Eight pages.

On the Relations of the Eastern Sandstone of Keweenaw Point to the Lower Silurian Limestone.

American Journal of Science, 1891. (3). XLII., August. Science, 1891, July.

The South Trap Range of the Keweenawan Series.

American Journal of Science, 1891. (3). XLII., 417–419.

Catalogue of the Michigan Mining School, Houghton, Michigan, 1890–1891. 102 pages.

Report of the Director of the Michigan Mining School for 1890–1891. 59 pages.

1892.

A Sketch of the Geology of the Iron, Gold and Copper Districts of Michigan. 113 pages.

Report of the State Board of Geological Survey. Lansing. 1893.

Serpentines of the Coast Ranges in California.

American Geologist, 1892. IX., 277, 278.

Report of the State Geologist, 1891–1892. 16 pages.

Subdivisions of the Azoic (Archæan) in Northern Michigan.

Science, 1892, XX., American Journal of Science, 1893, January.

Sandstone in the Copper Region.

The Engineering Magazine, 1893, IV., 643.

Catalogue of the Michigan Mining School, Houghton, Michigan, 1891–1892. 175 pages.

(*d*). The general internal work of the school has gone on more harmoniously and smoothly than ever before, and but very little friction has resulted between the Faculty and students, although a goodly number of the latter have been sent away. This has been done quietly, and has been quietly acquiesced in, as the Faculty has endeavored always to be just and never to act except for causes that the students themselves have fully appreciated.

So far as the internal workings and advance of the school are concerned, it seems to the Director that the Board has much reason to be congratulated; and the Director has to point only to the proposed resignation of one of the professors on account of insufficient salary, and to the continued ill health of Professor Kidwell, brought on by overwork. The latter should be relieved, as far as practicable, until he recovers, for a complete break down on his part would be a serious loss to the school, as he is not only one of the best teachers, but also one of the most energetic, hard working and useful members of the Faculty.

In conclusion, the Director desires that the aim of the school may never be mere numbers, but how high and how thorough work can be done, hoping and striving to do the best.

§ 9. ANNUAL REPORT FROM THE DEPARTMENT OF MATHEMATICS AND PHYSICS OF THE MICHIGAN MINING SCHOOL.

October 29th, 1893.

DR. MARSHMAN EDWARD WADSWORTH,
Director of the Michigan Mining School.

DEAR SIR:—I have the pleasure of hereby submitting to you my annual report of the departments of Mathematics and Physics of the Michigan Mining School for the year beginning 1891.

The following table shows the number of classes taught by me during the year, together with the size of each class, the number of hours per week, and the number of weeks each class has been taught:

DEPARTMENT OF MATHEMATICS.

First Year Students.

Classes.	No. in Class.	No. Hours per Week.	No. of Weeks.	Term.
Higher Algebra	32	5	14	Fall, '91
Trigonometry (Plane)	31	2	14	Fall, '91
Analytical Geometry	32	5	14	Winter, '92
Trigonometry (Plane and Spherical)	24	2	14	Winter, '92
Analytical Geometry	29	5	6	Spring, '92
Higher Algebra	32	5	14	Fall, '92
Trigonometry (Plane)	32	2	14	Fall, '92

Second Year Studies.

Classes.	No. in Class.	No. Hours per Week.	No. of Weeks.	Term.
Dif. and Integ. Calculus	16	5	14	Fall, '91
Analytical Mechanics	12	5	14	Winter, '92
Dif. and Integ. Calculus	29	5	14	Fall, '92

DEPARTMENT OF PHYSICS.

First Year Studies.

Classes.	No. in Class.	No. Hours per Week.	No. of Weeks.	Term.
Higher Physics	29	3	14	Fall, '91
Higher Physics	30	3	14	Winter, '92
Laboratory Physics	21	15	2	Spring, '92
Laboratory Physics	21	10	4	Spring, '92
Higher Physics	34	3	14	Fall, '92

Not only has the quantity of the work done by the students of these departments during the past year been considerably more than that of the year previous; but its quality has been considerably improved. Both of these results, I think, have been, in part at least, due to a better preparation of the students *before* entering upon their course of study in this school. As a consequence, a larger number of these students will be able to complete the course in the alloted time—three years—instead of being obliged to extend the time of their study upon it for four years.

While I have found the preparation of entering students, as a rule, to be better than formerly, as indicated in the preceding paragraph, yet I find some notable exceptions to this rule, and I am again constrained to urge, on the part of those preparing for entrance into this School, *the utmost thoroughness in the studies required for entrance.*

The methods of teaching in this School and its requirements differ widely from those of schools where most of the emphasis is placed upon the theoretical part of the studies, instead of combining the theoretical and practical, with especial emphasis upon the practical applications of scientific knowledge, as is notably the case in the Mining School. For these reasons I would also advise those preparing for entrance upon the first year's work to use their time on a thorough review of the studies required for entrance, rather than in trying to prepare for advanced standing.

In my teaching I labor continually under at least three serious disadvantages:

First—The attendance has become so much larger than formerly, that my classes are too large to teach as successfully as I would like; for, in order to prepare the student thoroughly for the eminently practical and very interesting parts of the course which follow the studies of these classes, he should be called upon to recite and to solve and explain problems oftener than is possible with classes as large as they now are in these departments.

Second—The time of recitations in these departments is unfavorable in the first two terms of fourteen weeks each, as they all come in the latter part of the day, when the students are already weary with the day's work. This is especially true of the students of the first year, whom I am obliged to teach by gas light one hour a day for the greater part of two long terms.

In rigid mathematical work, the earlier part of the day is certainly preferable. This is especially true when the student is otherwise engaged upon work that draws his mind almost altogether from mathematical thinking.

Third—The wide difference in the ability and preparation of the students makes it thoroughly embarrassing and very difficult to successfully instruct them when all are put into the same class. Much work and annoyance are brought to the Instructor also by this uneven grading, and the fact that so many "conditional examinations" have to be held for those students who fail in the first examinations.

My impression, too, is that where seven hours a day are required in recitation and laboratory work, not enough time is secured by the student to properly prepare his lessons. This I am confident is the case with the first year students.

In my report for last year I predicted that the class in the Physical Laboratory of this year would be fifty per cent larger than that of last year. The estimate then made proved to be correct, as twenty-one took the laboratory work last spring, whereas fourteen took the preceding spring.

In consequence of the great size of the class and the incomplete equipment of the Laboratory, the Instructor, at his own request, and in accordance with the vote of the Faculty, was permitted to divide the class into two sections, teaching each section ten hours a week, thereby adding five hours a week of extra work for himself.

This was found to be more profitable, under the circumstances, than to try to keep the whole class together fifteen hours a week.

Some extra lectures have been given during the year, both in Mathematics and Physics, upon which the attendance has been commendable.

Two hours per week of additional instruction in Mathematics is to be given hereafter, during the winter term, to the second year class.

The Professor of Mining Engineering has expressed the desire that this department should give some instruction in the use of the method of least squares, while the Professor of Metallurgy also expressed a desire that the mathematics of Ore Dressing be taught by this department. I think it desirable that both of these topics be thus taught.

The first need in this department is a larger recitation room, as the classes have already outgrown the present recitation room and are only temporarily provided for in the recitation room of the department of Mining Engineering. The mathematical recitation room was constructed too small for classes even of ordinary size. The second need is that the classes be divided into sections of proper size and more uniform ability. Were this done, the first need would be changed to that of an additional recitation room some larger than the present mathematical recitation room.

Such a division of classes would require an assistant in this department, as the present incumbent already has more teaching than he can do well, in connection with his duties as Secretary of the Faculty (including those of Registrar), the work of which position, in consequence of the largely increased attendance of the School, absorbs much of his time and energy and, in fact, makes his work unusually continuous during the school year and both perplexing and arduous.

I am thoroughly convinced as I indicated in my last annual report, that such a division, with an assistant, would be for the best interests of the School and the students. And should the wide difference in preparation of the entering students largely disappear, as it probably will, yet, with the present rate of increase in attendance, the necessity of such action will still remain on account of the larger size of the classes.

There is also a need of increasing the number of standard works of reference on the subject of Mathematics in the Library.

The most prominent needs of the Department of Physics are:

First—An addition to its equipment to meet the increase in the size of the classes. Two years ago the class in the Physical Laboratory numbered fourteen, last year twenty-one, and it is altogether probable that this year will see it increased by another fifty per cent. An appropriation of not less than $4,000.00 is needed for permanent equipment during the years 1893–94, and $500.00 for current expenses.

Second—A room free from vibrations, for work with mirror galvanometers, is greatly needed.

Third—The classes have already become so large in this laboratory that an assistant is *imperatively* needed. Where the instructor gives considerable personal attention and supervision to each student, as he must in such work, in order to secure the most commendable results, the number under his charge ought not to be large. With the prospect of a still larger class next spring than last the need becomes more urgent.

This department also needs a larger number of standard works of reference in the Library, especially those treating of Physical Laboratory work and methods.

During the year, in addition to the increased attendance in these departments and the greater amount and improved quality of the work, some increase of facilities for better work have been provided. Among these, in the department of Mathematics, are blackboard crayon compasses, mathematical solids, special blackboards with pulley attachments, for illustrating some of the principles of mechanics, and a large spherical blackboard with detachable mountings and a holder designed by the instructor.

The Physical Laboratory has been arranged for darkening with a system of spring roller, black oilcloth curtains which operate easily, quickly and very successfully, and about $1,200.00 have been expended in the purchase of apparatus mostly for the use of students in experimenting upon the subjects of light and electricity; as a consequence, the work on these subjects was much more efficient and interesting than the year previous, though owing to a delay in receiving the apparatus the time for its use was too brief.

With all the valuable records concerning the entrance and standing of students necessarily in my hands, as Secretary of the Faculty, it would seem wise to have a fireproof safe for their safekeeping.

Respectfully submitted,

(Signed) ARTHUR EDWIN HAYNES.

§ 10. REPORT OF THE DEPARTMENT OF CHEMISTRY.

To September, 1892.

The plan of instruction in this department was not materially changed during the year just ended. It is true that certain modifications, which my first year's experience at the School had suggested, were made but in the main it has been my aim rather to carry out the programme given in my first report and which is more fully stated in the last annual catalogue of the School.

The distribution of the work, and the attendance in this department were as follows:

First Year.

The number of students enrolled at the commencement of the fall term was thirty-six—an increase of eight over the corresponding period of the preceding year. With two exceptions these students worked in the laboratory, and the lectures and recitations were attended by thirty-three. The fundamental principles of the science, and the chemistry of the non-metallic elements formed the subject of the first term, during which three hours were weekly allotted to class-room instruction and four to the laboratory exercises. The subject was continued for six weeks in the winter term; the metals were then taken up in the recitations, which were held twice each week till the end of the School year.

The laboratory exercises which had been discontinued after the sixth week of the winter term, were resumed in the spring term, when thirteen hours a week could be devoted to them.

"Richter's Inorganic Chemistry" was used as a text-book in the recitations; the guides in the practical exercises were Smith and Keller's "Experiments in General Chemistry" and Eliot and Storer's Qualitative Analysis. A brief course was also given in blowpiping. Examinations were held at the close of each term.

A number of students pursuing special courses made such progress as to complete a considerable portion of the second year's work, while several of the regular students having failed to pass the examinations and to attain a sufficient standing, were advised to repeat the work of the first year.

The number passed was twenty-one.

Second Year.

The systematic course in Qualitative Analysis of the fall term was attended by fourteen students. Twelve out of the fifteen hours assigned to this subject were spent in the Laboratory, and of the remaining three two were used for recitations with "Fresenius" (London edition), as text book, and one for the study of "Oxidation and Reduction." Mr. Sharpless had charge of the last named subject; he also rendered excellent assistance in the laboratories.

This course was continued and completed during the winter term by all the students except one, and the subject of Quantitative Analysis commenced. The text book used was Fresenius's.

Third Year.

Only four students were allowed to enter the class in Quantitative Analysis at the beginning of the fall term. Twelve hours a week were devoted to this branch during the first term (one being a recitation), and one hour less during the winter term. With one exception these students did not make sufficient progress to take up Metallurgical Analysis.

A course of lectures was given on Volumetric Methods.

Three students took special courses, and one of these completed the advanced course in the technical methods of analysis.

The Lecture Room and the Laboratories have received numerous valuable additions. They are, in my opinion, among the best equipped in this country. The chief desiderata are special forms of apparatus for technical analytical methods, and better facilities for carrying out electrolytic work. The chemical branch of the Library is also still in need of sets of scientific journals as well as many works of reference.

(Signed) HARRY F. KELLER.

October, 27th, 1892.

§ 11. M. E. WADSWORTH, *Director:*

DEAR SIR—I beg to submit the following report upon the present conditions and future development of the Department of Chemistry.

On taking charge of this department with the beginning of the current term I found it, as I am very happy to say, in a very satisfactory condition. I desire to express here my gratification at the manner in which my predecessor, Dr. Harry F. Keller succeeded in the reorganization and management of the department. His views regarding the mode of teaching Chemistry in an institution such as the Michigan Mining School coincide largely with those held by me.

It is most important for any man who will hereafter rise as an engineer, that is, who will apply himself to improve the means of transporting and transforming the raw materials of nature, must have a most thorough knowledge of the chemical properties of matter in general and of the metallic bodies in particular. A very large amount of valuable time has been and constantly is wasted by men of active brains in their inventions, by lacking this knowledge of what I would call the "rigid discipline of matter;" for wanting to make matter do what it cannot do. The instruction in Chemistry is not therefore a drilling to perform certain routine operations and obtain by them composition of a certain substance. Many practical men would see in the reaching of such direct practical results the only good that a training in Chemistry could do. Whilst this is necessary because useful, I do not consider it as of first importance. It is my intention to follow Dr. Keller's plan and devote the four hours weekly allotted to the first year class in Chemistry, during the remaining half of the fall term in such a way that two hours will be occupied by experimental lectures and the two consecutive hours of Thursday to recitations on those lectures, using Richter's Inorganic Chemistry as a text-book. During this time I propose to finish the non-metals and to implant into the students the chemical terminology along with the laws of physico-chemistry.

The winter and spring terms I propose to have devoted to experimental work by the students, and recitations from Richter on the metals. The students will be required to make a weekly written report on their experimental work, and responses to questions from Smith and Keller's catechism.

The second year's class I find fairly well advanced and making good progress in qualitative analysis. A majority of the class will be ready to begin quantitative work at the opening of the winter term, some even before then. Thus I expect to see as many as one-third of this class far enough advanced to avail themselves next year of the new course in Synthetic Chemistry. Yet I find that it will be advantageous to the class if I introduce one hour a week in recapitulating and learning new reactions, these latter forming as valuable a stock of knowledge as the multiplication table.

The third year men, not having had the advantage of the reorganized course, are not so far advanced. With the exception of two men, they began quantitative analysis only at the beginning of the present term. It is my plan that each student shall have made at least one successful separation of one important element in each group, before he undertakes to make use of any so-called technical method. I think it probable that two-thirds of the men will reach this standard; some of the men will go beyond it, and they will be enabled to get a working knowledge of the treatment of some of the most important organic compounds, such as fats and oils.

In proposing the course of Synthetical Chemistry I have had in view the desirability of inducing men of good capacity to prolong their stay at the school, and to become more thoroughly equipped for rising to prominence in after life. Technical or applied Chemistry is usually given in the form of didactic, copiously illustrated lectures, and recitations from text-books. Having delivered such a course for some years in another institution, I have come to the conclusion that the student wastes his time, and the professor his energy, in following such a course.

In my present experience techical Chemistry as such, that is, the commercial production of chemicals, cannot and should not be treated in the schools, because the technique is forever changing, and even if a school were provided with the great sums needed, it could not keep up the march of progress. What I call Synthetic Chemistry is that applied Chemistry which the school should and can treat of. It is simply experimentation in a certain direction with a useful or economic purpose. If I have established the conditions under which the coating of tin can be removed from sheet iron, so that the latter is left as such and capable of being used over, I have solved a problem of technical chemistry, and I need only to substitute large vessels and steam power for my glassware and stirring rods to make the invention commercial. In this spirit I propose to conduct my course of Synthetic Chemistry, or applied Chemistry.

I find that previous appropriations have been well spent. The store room and the laboratories are well stocked. The present scope of the school can be filled with the apparatus now here. But already the laboratories are crowded and only ten more students would require a doubling up; they could not be furnished with desk room and work advantageously.

There is now no room at the disposal of the department in which special operations requiring precision and equal temperature can be conducted; no room in which a student engaged on advanced work can mount and keep mounted a train of apparatus necessitating a strong ventilation under a hood. It is urgently needed that the present class room of the department should be converted into two work rooms, one of them to be used for gas analysis exclusively; the other for work requiring especial precautions, such as the handling of explosive compounds. For the class room work some other place should be found. The ventilation of the laboratory is very imperfect. After careful examination, however, it appears that the alterations involved in a reconstruction would be very expensive, and I do not urge for this reason any action in this matter for the present.

With the present number of students the classes have become so large that the students have to lose considerable of their time, for the reason that I cannot be attending but to one at a time in the laboratory. But as according to the proposed plan three-fourths of the time is allotted to laboratory work, great inconvenience results, even if the efficiency of the teaching is not impaired. This is notably the case with the experimental work of the first year's class. I would therefore respectfully submit the advisability of providing an assistant at, say, sixty dollars per month salary.

After examining the accounts it appears that each student consumes on an average in chemicals and apparatus the sum of twenty dollars a year. It will be safe, therefore, to fix the annual needs for the supplies to the laboratories for the two coming years at eighty times twenty, or sixteen hundred dollars.

In the course of chemical advance it has been found that all glass vessels are more or less attacked by pure water, and for certain work of extreme precision it is necessary to procure absolutely pure water. To do this an apparatus of platinum is needed; for such an apparatus the sum of two hundred dollars is required. I also find that all the weights need readjustment, and three new sets are required; for these and other incidental expenses, two hundred and fifty dollars per year are needed.

I beg to call your attention to the matter of supplying electrical current to this department. Chemical reactions depend largely on the accurate discernment of colors. Gaslight interferes much with the seeing colors correctly, and thus all the laboratory work of the students, during the dark hours of the afternoon, is necessarily defective. The electric light is, in its qualities, much more like the sunlight, colors being but very slightly modified by it.

In the second place, a strong and steady current—not alternating—is needed for the electrolytic work. I propose to introduce this line of metallic analysis much more prominently than it has been done heretofore, as the advance in making such work useful has been very rapid in the last few years. The Michigan Mining School should not be behind any other school of similar character. The current should be produced in the Mechanical Department and stored in accumulators, both for lighting and for electrolytic use. The storage cells themselves furnish many perplexing phenomena with which the students should be more acquainted practically, as well as learn the nature and intricacies of the generating dynamos.

Very truly yours,

(Signed) GEORGE A. KOENIG.

November 30th, 1892.

§ 12. REPORT OF THE DEPARTMENTS OF ORE DRESSING, METALLURGY, ASSAYING AND TECHNICAL CHEMISTRY.

DR. M. E. WADSWORTH, *Director:*

I have the honor of submitting the following report of the work done in my department between December 1st, 1891, and December 1st, 1892. Very respectfully,

(Signed) FRED. F. SHARPLESS.

(*a*). *Ore Dressing.*

During the fall and winter terms, September 14, 1891, to April 8, 1892, five students attended the lectures in Ore Dressing. The small number of students enabled us to make a very thorough examination of all of the stamp mills of the vicinity. Each student was required to draw up a sketch showing the method of treatment in, at least, one of the mills.

During the spring term the class of five students devoted four weeks to practical work in the stamp mill. Ten tons of a low grade auriferous and argentiferous quartz were treated.

The small amount of ore treated was due to the size of the class. With a class of ten or more the entire mill can be run at one time, comparative tests can be made with a greater degree of accuracy, and the checking by fire assays follows closely upon the mill work, thus enabling the student to change his method without the loss of time and material. With our small class the nature of the work was changed every day, and consequently the amount of work done was not so great as with the larger class of the previous year.

One of the students of the class was a native of Peru, having come to the School for the purpose of taking the work in Ore Dressing.

The students attended to the running of all machinery, the instructor making suggestions and giving advice when such seemed called for.

Samples of all material entering and leaving the various appliances were very carefully taken and assayed. The assay showed that poor work was done at first, but that the results improved from day to day as the sources of error were found and eliminated, and as the students understood better the working of the separating machinery.

The results obtained during the last portion of the time were as satisfactory as could be obtained in any well regulated stamp mill.

A large portion of the gold and silver in our quartz was contained in the associated pyrite. All of this pyrite was collected from the stamped rock, and is at the mill waiting treatment by chlorination and lixiviation. One of the problems given to and solved by this class was to determine the most economical method of obtaining pure gold and silver from this pyrite. The results obtained were not of the highest value, because all samples experimented upon were small. The treatment best suited began with roasting, but at that time we were provided with no means for roasting samples of working size. Since that time we have finished the construction of a furnace which will accomplish this object, and, indeed, it is so constructed that it would be suitable for the treatment of all refractory gold and silver ores that do not require smelting.

During the present term, September 19 to December 23, 1892, sixteen (16) students have been enrolled for the lectures in Ore Dressing. The course of this term is being given in about the same manner that it was given during the fall term of 1891. In the summer term, however, we propose to make the course rather broader than it has been. Each man will be given an ore, matte, or slag, carrying precious metal. After making an assay and an analysis of this sample he will be required to make a report as to the best and most economical method of treatment for recovery of the precious metal. We will also have a greater variety of ores to treat, this year, than formerly.

Our mill is in good running order, and is supplied with first class machinery of regular size, from the best shops.

The work of the course in Ore Dressing can never be considered complete until we have facilities for treating *all* classes of ores, and this cannot be done without the addition of a metallurgical laboratory.

One difficulty we experience at present lies in the procuring of ores exactly suited to our machinery. The purchasing of ores for this department would be much easier and accomplished with greater economy, if we could use *any* ore that might be offered to the school.

I think it advisable to add, from time to time, additional pieces of standard machinery, which will permit us to treat a wider range of ore, and so give the men a broader knowledge of the subject. For this reason I have asked for an appropriation further to equip the mill.

It is understood, of course, that the milling of the ores does not give us a product ready for the market. The mineral, amalgam, or concentrates, produced, must be subjected to some smelting operation; and again, the ores coming under the refractory class must be roasted or smelted, before they will yield their precious metal. To obtain a practical knowledge of the principles of the latter operations, it is necessary that these operations should also be carried out by the student. If we suspend our treatment of the ore when we have obtained it in the concentrated form, we only half finish the work, in this direction, which we have undertaken. The Mining School was established for the purpose of offering the student a thorough knowledge of ores and their treatment, and it is due to him that we carry into effect that which we have promised.

For these reasons, and for others I mention under the subject of metallurgy, it is deemed advisible to request the Legislature to make an appropriation for a metallurgical laboratory, so that this department may be as complete as are others of our school.

In regard to the literature on the subject of ore dressing, I would say that our library has been supplied with a few of the standard works, but there are many volumes we should yet have, if we pretend to make the course what it should be.

Appropriation for equipment, including apparatus, lecture specimens and drawings	$1,200
Annual appropriation for fuel, ores, freight, mercury, chemicals, repairs and additions in the stamp mill:	
For 1892	1,200
For 1893	1,200

(*b*). *Technical Chemistry.*

During the winter term, January 4 to April 8, 1892, no regular students were pursuing this course, but it was given to a number of special students, the major portion of whose work was Chemistry. The work was carried out as indicated in the catalogue for 1890–1891, twelve to eighteen hours a week being devoted to laboratory practice in Metallurgical Analysis.

The object of this course is to acquaint the student with the special methods of analysis that are in use in the laboratories of metallurgical establishments. Special prominence was given to the assay and complete analysis of iron ores, pig iron and steel, the determination of their ingredients—carbon, silicon, phosphorous, sulphur and manganese—the analysis of fuel, cinder, limestone, etc. The student was taught not only to perform the determination *accurately*, but also to work as *rapidly* as was consistent with the desired degree of accuracy. Complete sets of apparatus were procured and constructed for this work.

Owing to the facts that methods used in technical laboratories change from year to year, no text book was used. Detailed printed directions were furnished to serve as a guide; these were printed just previous to the work on each subject and contained the shortest and best methods known up to date, with references to the original papers, the most of which are to be found in our library. The course has proved to be both popular and instructive, several special students having elected it as the major portion of their work.

Additions to the apparatus for this work should be made from year to year, in order that we may keep pace with all advances in this most important branch of our practical instruction.

(*c*). *Metallurgy.—Fuel and Refractory Materials, Metallurgy of Iron, Steel and Aluminum.*

Fall term, September 19 to December 23, 1892.

Twenty-five students are attending the lectures and recitations of this course. The first three weeks were occupied with lectures and recitations upon Fuel and Refractory Materials.

While studying the Metallurgy of Iron and Steel, "Greenwood's Steel and Iron" is used as a text book; lectures are given throughout the course, about half the time being devoted to lecture work and half to recitation.

A new feature has been added to this course, which it will be desirable to introduce into all the courses of Metallurgy and Ore Dressing, viz., providing the students with blue prints of all machines, apparatus, etc., spoken of in the lectures. This enables the student to obtain a clearer idea of the subject under consideration than the exhibition of a drawing which he can see only for a few moments. We are enabled to carry out this work through the equipment of the photographic laboratory, which has been materially increased during the past year.

Metallurgy of Copper.

Fall term, September 19 to December 23, 1892.

Fifteen students are attending this course.

Peters's "American Methods of Copper Smelting" is used as a text book.

The first few weeks of the term were devoted to a close study of this book; later we discussed methods not strictly American. Excursions have been made to the copper smelting works of this vicinity, where the practical working was observed in detail. Whenever we have made these excursions the management has always treated the students with the greatest consideration, taking great pains to show them the details of the smelting operations.

Metallurgy of Lead, Gold and Silver.

Winter Term, January 5 to April 8, 1892.

Four students attended the lectures of this course. The subject was given entirely by lectures, no suitable text-book being available. Frequent references were, however, made to the standard works, many of which are in the library.

The sets of journals now in the library are in several cases incomplete; it would be advisable to have these completed at the earliest opportunity.

We have had a large number of drawings made, illustrating modern metallurgical appliances. The use of these adds greatly to the interest taken in the course, and the benefits obtained by it; as do also numerous photographs and samples of metallurgical products, which I am obtaining from all parts of the country as rapidly as possible. The money necessary for gathering such a collection is considerable, but the benefit obtained by their use overbalances, by far, the expense incurred.

In regard to a metallurgical laboratory, I can do no better than repeat what was said in the Director's Report for 1886 to 1891, and what was there said cannot be too strongly insisted upon.

It must be admitted that the course, given as it is, with no opportunities for applying the principles studied, is not on an equal footing with the other courses of our School. Principles without practice can make but little lasting impression upon any man's mind, and if one undertakes to put into practice, years later, the principles he learned while in college, he will find himself at a great disadvantage, unless he studied their practical applications at the same time. "The practical knowledge a boy picks up while yet under twenty, is the knowledge that makes a practical man of him."

Reasons may be given why the state cannot afford to instruct in practical metallurgy; but are not these reasons more apparent than real? The same thing (it is too expensive) was said only a few years ago concerning mechanical laboratories, but today we have them all over the country and all of our best mechanical engineers are coming from them.

The object of the Mining School is to offer practical knowledge to the student; our laboratories—chemical, physical, mineralogical geological—and in short all departments bear witness of this, excepting that of Metallurgy alone, and the only reason we have not been able to supply this department with laboratory facilities is because of the necessary expense which must be incurred.

The want of a good Metallurgical laboratory is felt all over the country. Many schools and colleges offer fair courses in Metallurgical Chemistry, but none of them are supplied with the means of offering that work which the student of Metallurgy is most anxious to pursue. Such a student must go to Germany, if he wishes to pursue both theoretical and practical work in this direction. In this country he can study only the practical side by spending several years at a smelting furnace, and then obtaining the theoretical education at some college. Unless he limits himself to one subject, he will find life too short to accomplish his object by this method. A smelting laboratory, such as the Mining School should have, will fill this gap in technical education, and our students will no longer be forced to go abroad.

A Metallurgical laboratory is greatly needed for the accomodation of our mining men. While a chemical analysis may show very accurately the composition of a mineral or rock, it does not show how much mineral may be obtained from a successful smelting of the ore, nor how the ore may be most economically treated. To obtain these working results the explorer must send his ore to one of the several private testing works, and pay an exorbitant fee for professional opinions. In a good State laboratory, this work could be done better than by smaller concerns, and at a cost merely sufficient to cover running expenses.

It will be noted that among the estimates no apparatus has been asked for to illustrate the practical metallurgy of iron and steel.

While the metallurgy of iron is just as important as that of the other metals, it cannot be carried on on a small scale and give results of any practical value, and the establishment of a plant for the manufacture of steel would be so expensive that for the present it is advisable that this be omitted. In planning the building, however, distribution of the apparatus will be so made that a steel plant may be added at some future time if found desirable.

We did not ask for this laboratory before 1891, because the future success of the School might have been questioned, and the state would not have been sure of an adequate return for the money invested. The future of the Mining School is now well assured, for not only in Michigan, but in all parts of the country do we hear it well spoken of. Journals comment favorably upon our work, our graduates are eagerly sought, and inquiries concerning the work pour in from all sides.

For the reasons I have mentioned here, and under "Ore Dressing," and for many others too obvious to mention to any one interested in the success of the School, I think it wise that the state should make an appropriation for the purpose of establishing this Metallurgical laboratory.

Estimate of Proposed Metallurgical Laboratory.

Water jacket copper smelting furnace; water jacket lead smelting furnace; Brückner roasting cylinder; castings for reverberatory smelting furnace; blower for cupolas; apparatus for Hill's Process; apparatus for electrolytic deposition of copper; Blake crusher; Krom's rolls; tools, slag pots, shafting, pulleys and belting—bid of Fraser and Chalmers		$3,210 00
Freight on above mentioned apparatus; fire brick, fire clay, erecting of furnaces—estimated by Frazer and Chalmers		3,088 00
Carpenter work, estimated by local contractors		1,050 00
Stone work:		
925 perches rubble, pointed inside and out at $3.00		2,775 00
12,000 pressed brick at $30.00	$360 00	
7,000 common brick at $18.00	126 00—	486 00
Fire brick furnaces, chimneys and common brick work for Assay Laboratory—estimated by local contractors		480 00
One large pair of scales for weighing barrows		125 00
Excavation—estimated by local contractors		80 00
Filling—estimated by local contractors		125 00
Brick arches over doors, windows and passage in basement of Assay Laboratory—estimated by local builders		320 00
Cement flooring—estimated by local builders		112 00
Iron flooring—estimated by local foundries		1,382 00
Foundation for iron flooring—estimated by local builders.		75 00
Iron pillars and "I" beams		185 00
Iron roof and iron trusses—estimated by Berlin Iron Bridge Co.		2,500 00
Freight on and erection of the same		250 00

Wire rope, sheaves, pulleys and shafting, for bringing power from stamp mill to laboratory	150 00
Lighting—estimated by local plumbers	112 00
Heating office and balance room	75 00
Furnishing office and balance room	175 00
Plumbing, consisting of running water to and from all furnaces, casting tank in main floor, and piping in dressing room	225 00
Casting trough	55 00
Architect's plans	330 00
Total	$17,260 00

It will be noticed that the total is $270.00 less than the total estimate made in 1891.

Two items have been added, viz., $250 for the erection of the roof, which item was accidentally omitted from the previous estimate, and the item of filling, which is introduced because of a proposed change in the site of the building.

It will also be noticed that a number of the items have been diminished, viz., bid of Frazer and Chalmer's, estimate of same company for erection of furnaces, estimate of stonework and estimate of excavations, a total of $645.00 The cause of this reduction is that during the year 1892 enough money was appropriated from the general funds of the School to permit of the construction of one furnace for the roasting of ores. The material and labor put upon this furnace, which stands within the site of the proposed laboratory, are in part permanent and part temporary. The furnace and its accessories cost about $645.00. This corresponds to the decrease in the estimate. The furnace is protected by a temporary shed, which will be removed upon the erection of the main building.

Annual appropriation for lecture specimens, drawings, models, etc., for 1892	$300 00
Annual appropriation for lecture specimens, drawings, models, etc., for 1893	300 00

(d). *Assaying.*

The course in Assaying occupies seven hours of each day for two weeks in the spring term.

During the spring of 1892 ten students were instructed in Assaying, several of them being special students in this subject.

No text book was used, but notes were printed by the instructor and furnished to each of the students. Almost all of the time was devoted to laboratory practice, only a few hours being devoted to lectures.

Assays were made of lead ores, gold and silver ores, and copper "mineral;" altogether about seventy-five determinations were made. While the work in the stamp mill, which follows that in the Assay laboratory, was in progress, twelve samples of the crushed quartz were assayed daily. Numerous assays were also made in connection with the experimental work, while determining the best method for working our ore; so that the course in Assaying lasted, practically, throughout the entire spring term.

This laboratory is well equipped, and until the growth of the School demands the present laboratory for other purposes, nothing except the regular annual supplies need be procured.

There is always some danger of fire from this department, and though every possible care is taken, I would advise, for the safety of the main building and convenience of the department, that the Assay laboratory be moved to the Metallurgical building as soon as one is erected.

Appropriations Asked For.

Annual appropriation for fuel, ore, crucibles, re-agents, repairs to furnaces, etc.:—

For 1892	$400 00
For 1893	400 00

(e). *Photography.*

The money expended in this department during the last two years has enabled us to fit out one of the smaller rooms as a Photographic laboratory.

The equipment of the laboratory is fair but still incomplete.

The apparatus that we have enables us to make photographs of all drawings, prints, the original subjects that we desire to show to the classes. From the negatives blue prints are made and distributed to the students, thus enabling them to make their lecture notes of greater value.

The work of making the photographs requires a great amount of time, and for this reason is yet far from complete. The Department of Mining, Ore Dressing and Metallurgy are, however, using the apparatus considerably, and we deem it one of the most profitable additions that has recently been made to the equipment of the School.

Appropriations Asked For.

Appropriation for further equipment	$400 00
Annual appropriation for carrying on the work of the same—	
For 1892	250 00
For 1893	250 00

Houghton, Michigan, November 14, 1892.

§ 13.

DEAR SIR:—I herewith hand you my report of the work of this Department for the year 1892.

Yours very truly,
EDGAR KIDWELL.

The DIRECTOR.

(*a*). *Drawing.*

The course in Drawing as laid down in last year's catalogue having been found efficient, no changes of consequence have been made in it. Warren's *Elementary Projection Drawing*, which was used for several years as a text book, has been discarded, and since September, 1892, the work of the first year has been taught mainly from Angel's *Practical Plane and Solid Geometry*. This work having proved itself well adapted to our needs, will be adopted for the coming year. In the second year the work has been made more efficient by increasing the scope of the construction drawing. The patterns and other work made in the shops during the past summer have proven to be of great value to us when teaching machine sketching and production of working drawings from the model. It is, therefore, proposed to design additional models especially adapted to the needs of the department of drawing, and construct them during the next term of shopwork.

To render the course in Designing more efficient, the order in which the subjects are discussed in the lectures on Mechanical Engineering has been changed somewhat, with the view of taking up at the close of the term some important problems in location and design of steam plants. The hours available for the work in designing in the present three years' course are entirely too few in number, as the term is about over by the time the student has been made familiar with the more elementary portion of the work. Any further desired information concerning the details of the course in drawing may be found in the catalogue for 1891-1892. Referring to my report of last year, I would state that the large printing frame therein mentioned was completed, and it is in operation. Owing to the increased number of students this year, it has been found necessary to provide three smaller frames adapted to our standard size of sheet, and these will be in operation inside of a month. A drying rack to be used in connection with the blue printing outfit has also been added.

I append to this report a table of attendance in the entire department under my charge. It shows at a glance the steady increase in the number of students, and shows plainly the necessity for additional room. In my last report I stated that by re-arranging the drawing tables and putting in three new ones I had provided accommodations for sixteen additional students, but this increase in capacity of the department has not been sufficient. Every desk is now occupied, and though only one class works at a time, the room is entirely too crowded. Owing to our limited corps of instructors it is not possible to split the classes, hence the only practicable method of relief is to provide a larger room. If this be done in connection with the proposed new building for the workshops and heating apparatus, the interest on the money expended in providing a suitable room will be materially less than the expense necessary to provide additional instructors needed in the other departments in case the classes are divided into sections.

(*b*). *Mechanical Engineering.*

The scope of the work in this subject has not been extended for the reason, as given in my last report, that any increase would result either in overburdening the student so that he could derive no profit from the course, or else the instruction in some other branch equally important would have to be curtailed. We have no time in the present course for practical work in testing, but hope that something in this line can be done during the winter term by making an arrangement with the class to work on Saturdays. This deficiency is provided for in the four years' course by the introduction of a month's work in testing during the summer of the fourth year.

The Four Year's Course.

In the Catalogue for 1891–1892 will be found a table of hours for the Four Year Course, an inspection of which will show a material increase in the number of hours to be devoted to Drawing. During the first term of the first year, the instruction will be confined to the same subjects now taught in that term, but the increased time will permit more extended work in Descriptive Geometry. The instruction in Topographical Drawing will be made more exhaustive by devoting to it ten hours per week for an entire term, instead of eight hours per week for only eight weeks, as at present. The course in Constructive Drawing and Machine Sketching will be expanded, and occupy two terms of the second year and one term of the third. Graphical Statics will occupy the winter term of the third year. The instruction in Mechanics of Materials, Mechanism, and a portion of the Mechanical Engineering, will also be given during the third year, so that at the opening of the fourth year the student will be prepared to enter intelligently upon the work in Designing, which will be continued through two terms, instead of only one term as at present.

(*c*). *Electrical Engineering.*

I desire again to call your attention to the need of sufficient electrical apparatus to give the students some practical knowledge of the application of the principles taught in the class room. In each report given by me since I have been in charge of this Department, I have stated at length the reasons why such an apparatus is an absolute necessity. The expense of providing sufficient equipment would not be great, as the more elementary work could be done in the Department of Physics, which is already provided with some of the apparatus needed. The School is now provided with a No. 4 Edison dynamo, a two-horse-power Sprague motor arranged to drive the oil tester, and I have partially completed the wiring of the shops for incandescent lighting. The students will be taught to manage this plant, and will thereby obtain some practical knowledge, but I consider that more than this should be done if the School is to maintain its proper standard of excellence. By making some additions to the equipment of the Physical

Laboratory, and providing a battery of storage cells and some measuring instruments adapted to the uses of the engineer, rather than the laboratory physicist, the course of instruction could be made sufficiently broad to answer the needs of a Mining Engineer. This equipment would also facilitate, in many ways, the work of several other departments. At present the current for all the electrolytic work done in the Chemical Department is furnished by a battery of crowfoot cells, stored in the Quantitative Laboratory. Such an arrangement, if made of sufficient capacity to answer the requirements of the Chemical Department with its present number of students, would be entirely too bulky, expensive, troublesome to maintain, and of no value for any other purpose than electrolytic work. In the report of the Professor of Chemistry, to which I beg leave to refer you, will be found a statement of the reasons why it is highly desirable that the laboratories under his charge be equipped with a number of incandescent lamps, ready for instant use at any part of the day. The instructor in Petrography, for reasons given in his report, requires in his lectures a projecting lantern operated by an electric or a calcium light. The latter, in addition to the danger of explosion, would be expensive and troublesome, as the tanks could not be refilled at any place nearer than Milwaukee.

All these needs can be supplied by installing a battery of storage cells of such capacity that it will need charging not oftener than once per week. It is not possible to obtain the current from outside sources, as the local Electric Light Company run their station only from dusk to dawn, hence their plant is idle at the very time we need it. Beside this, they use alternating currents, which are of course useless for electrolytic work.

Such a battery of storage cells could be placed in the proposed new building for this department, and form a most important part of our apparatus for practical work in electrical engineering. The field of usefulness of the accumulator is daily growing, and it is absolutely necessary that we recognize that fact to the extent of giving the students an opportunity to become practically familiar with its operation and management, and such familiarity cannot be obtained from works or lectures.

(*d*). *Shopwork*.

The arrangement by which special students may be admitted to the course in Shopwork went into effect during the past summer. Five men applied for entrance, of whom two were not accepted owing to lack of sufficient preparation. During the coming summer a much larger attendance of special students is expected, as it was not generally known last year that any provision had been made for those wishing a special course. Two men have already signified their intention of coming next summer, and when it becomes more generally known that such an opportunity is open to those who desire to obtain some knowledge of machinery and shop practice without having to spend several years in school, the applicants for admission will probably be greater in number than we can accommodate.

The rearrangement of the workshops, mentioned in my last report, was completed by the opening of the course in July. The utmost care was taken to utilize every foot of space, but owing to the smallness of the two rooms at my disposal, it was found impossible to provide space for all the tools needed, and work-benches sufficient to accommodate classes of such size as are now in attendance. Owing to the paramount importance of practical work in testing, I was obliged to provide quarters for the testing apparatus by partitioning off part of the pattern shop, though the original room is far too small for the shop alone. The testing room thus provided is so small that, with even its present limited equipment, I am unable to put students at work on each machine without their being in each other's way. With the jig and hand saws, lathes, etc., at work in the pattern shop, it is impossible to keep the dust out of the testing room, which makes it impossible to do some classes of work while the pattern shop is in operation. In the shop we have no place for a planer or mortiser, nor can we find space for over two lathes, while we need at least five. There is no room for storage of material or patterns. To provide benches for the number of students we shall have to accommodate, the vises have had to be put only five feet apart, and in consequence the students are always in each other's way. In the machine shop the power tools had to be placed so close together that when a man is at work on each tool it is extremely difficult for one to walk about the rooms, particularly if carrying any material. I need not call your attention to the fact that, owing to liability of some one getting caught in the belts, or gearing, such an arrangement is, in any event, dangerous, but particularly so in our case, because the student generally has had no previous experience with machinery, and therefore does not recognize the necessity of being careful.

In spite of all this undesirable crowding of the machinery, I was unable to provide work-benches for over ten students in the machine shop, and even on these the vises are too close together. We have only one speed lathe, whereas we should have three, but I could find no room for them. The space about the engine is so constricted that it is almost impossible to locate a pair of scales for power tests with the friction brake. We have no condenser, and no room for one even if we had it. This seriously interferes with our engine testing, but there is no way of improving matters while we stay in our present quarters.

During the past summer the boilers were completely overhauled and the defects in the original setting and arrangement of flues were corrected as far as possible while the boilers remain in their present location. The architect of the building made no provision for examining and cleaning the mud drums, hence the proper inspection and cleaning can be done only at long intervals and with the greatest difficulty. The boiler room is so short, and the space between boiler front and the retaining wall of the pit so narrow, that when any fuel is stored in the room the fireman is unable to use a scraper with sufficient length of handle to run the entire length of the flues. The wood used for firing during the fall and spring is only about six feet from the boiler front. The room above the boiler, occupied by the Geolegical Survey, has only a maple floor resting on 3 x 12 white pine joist, and the underside forming ceiling of boiler room is protected only by a coat of plastering. It surely needs no lengthy argument to convince anyone of the great danger of such an arrangement, owing to liability of fire. It must also be remembered that the School is situated over a mile from the village, and that the latter is provided with only an old fashioned hand fire engine, which in event of a fire at the School would be well near useless, even if there were at hand abundant facilities for obtaining water. Unless it is absolutely necessary, boilers should under no circumstances be located under the main part of the building, and if so located every possible precaution should be taken to minimize the danger from fire and explosion. Such precautions seem to have been entirely neglected in the design of the present boiler plant, and it is absolutely necessary for the safety of the building that the boilers be removed and put in a building designed especially for them. One of the boilers has been piped to furnish steam for the shop engine, as contemplated in the original design of the building, and it is unnecessary to point out that in a building occupied by ninety to a hundred people, a boiler carrying sixty-five pounds of steam introduces elements of danger that should not be permitted to remain. I have adopted every precaution in my power to reduce the danger, and endeavor to be present personally whenever the boiler is used for power purposes, but in spite of this accidents *may* occur to *us*, just as they do to *others.*

In my report of last year I mentioned the need of sufficient *space to store* all the fuel necessary for one year's use, and *though a temporary* shed has been erected to answer this need in part, the arrangement is far from being satisfactory. The coal must be brought out little at a time, and carried down a flight of steps to the boiler room, in all sorts of weather, as there is no space in the rooms for more than a couple of tons. All the ashes and refuse must be carried up these stairs and deposited in an unsightly pile at the rear door of the building, unless carted away daily—a course forbidden by the expense.

The only practicable method I can see for overcoming these evils, and obtaining relief from the present overcrowded conditions of the quarters occupied by this department, is to construct a separate building, designed especially to accommodate the shops, testing room, drawing room and the heat and power plant.

I therefore present for your consideration floor plans of a building which I have designed to answer all these requirements. The machine shop occupies the ground floor in the main building; directly overhead is the pattern shop and professor's office, while on the third floor is a drawing room capable of accommodating as large a class as an instructor can handle at one time. Two rear wings to the main building provide for the Electrical Laboratory, two class rooms, office for the instructor in drawing, and store rooms for tools, batteries, and lumber.

The boiler and coal storage room occupy a shed between the main building and the rear wings. The coal room will be sufficient to carry a year's supply of coal, and the floor being on a level with that of the boiler room, the fuel can readily be wheeled in and dumped before the boilers. This part of the building being only a single story in height, separated from the main building by a stone wall two feet thick, and devoted exclusively to the boilers, avoids the dangers inherent to the present arrangement, besides providing ample space for proper inspection and cleaning of the boilers. As the ground upon which it is proposed to locate the building slopes toward the lake, the water line in boilers will be sufficiently below the main grade to allow steam pipes for heating the present building to run under ground without the use of any special means of keeping the pipes drained. The grade at rear door will be even with boiler room floor, obviating any necessity for transporting ashes and refuse up a flight of steps, as in the present arrangement.

In planning the building I have endeavored to economize in every possible way, and include nothing that will not, when the structure is completed, be of direct value in carrying out the work for which the building is needed. The cost is therefore based on the supposition that the exterior is to be as plain and unpretentious as possible, with walls of pointed rubble work, instead of ashlar as in the present main building. While the appearance of such a structure may not be all that one could wish, I consider it more advantageous to the School to expend money in equipment needed for teaching rather than in ornamental exteriors to its buildings.

That the general public is rapidly recognizing the advantages of this School to the mining world, and the wide effect of its teachings, is evidenced in this Department at least, by the increasing tendency of manufacturing concerns to lend or present to us for use in our laboratories such machines and appliances as they wish to place before the mining community. During the past year I have received more such material than ever before. One electrical company alone has agreed to place here electrical machinery aggregating in value about $2,200, provided we are in a position to install and operate it properly, that it may be a credit to them as well as to us. I expect to obtain more such material during the coming year, provided I can find quarters for it. At present, our room being insufficient for even what we have on hand, I am unable to accept anything sent on the usual condition, namely, that we must operate it that the students may obtain the information for the imparting of which the manufacturer gave the machine. I need not inform you how absolutely necessary it is to be able to accept all such offers of assistance from outside sources, and consider that if we are forced to decline such offers, by reason of insufficient room, such action will create in the public mind an indifference and lack of confidence in the School which no amount of good work hereafter can remove.

The estimate for furnishing includes not only the actual furniture, work-benches, drawing tables, tools, etc., required to accommodate the increased number of students, but also the money required for removing the equipment of the present shops, removal and resetting of the heating boilers, and installation of the battery of storage cells, the need of which I called to your attention when discussing the subject of Electrical Engineering.

Estimates.

New building for shops, drawing room and heating plant (building only)	$30,000 00
Furniture, repairs and removal from present building	12,500 00
Total	$42,500 00
Annual expense of shops, drawing room and department of Mechanical and Electrical Engineering	600 00

Table of Attendance in this Department—Drawing.

Term.	Year	1st Year Students	2nd Year Students	3rd Year Students	Totals
Fall	1890	28	6	*none	34
Winter	1891	24	6	6	36
Fall	1891	33	19	3	55
Winter	1892	22	19	2	43
Fall	1892	35	25	18	78

*Graphical Statics changed from second to third year, hence omitted during year 1890-91.

Subjects.	1890-91	1891-92	1892-93
Steam Engineering, etc	8	....	15
Properties of materials	14	18	†25
Mechanism	6	16	25
Electrical Engineering	8	18	15
Mechanics of materials	7	2	18
Shopwork	9	‡ none	18

†Estimated from size of present Junior class. Lectures in these subjects are given in Winter Term.

‡Shopwork was transferred from first to second year, hence the course omitted in 1891-92.

§ 14.

October 29, 1892.

DR. M. E. WADSWORTH,
Director, Michigan Mining School:

DEAR SIR,—I herewith submit my annual report, covering the work done in the Mining Engineering Department for the school year of 1892.

The subjects in charge of this Department are Mining Engineering, Hydraulics, Surveying and Topographical Drawing.

Very respectfully submitted.

(Signed) F. W. DENTON,
Professor of Civil and Mining Engineering.

(a). *Mining.*

The method of conducting this course has been outlined in a previous report, and since that report was made no change has taken place in the method of instruction.

During the winter term the class in mining numbered twenty, and eighteen of these students formed the class during the work at the mines in the spring term following.

During the winter term, in connection with the lecture room work, the class in Mining spent three Saturdays in the Atlantic Mine, two in the Quincy Mine, and one each in the Tamarack and Osceola Mines. In addition to these visits by the class in mining, a visit was made to the Franklin Mine for the benefit of the first year students only.

Owing to the increased number, it is no longer possible to take all of the students on each of these excursions.

The six weeks of the spring term were spent at the mines of the Gogebic and Marquette Iron Ranges.

The first two weeks were occupied in making surveys of the Imperial and Lowell Mines, situated near Bessemer, Mich. These two mines are on adjoining properties but are not connected underground.

Complete surveys were made of both mines, maps being promised to the companies in return for the privileges of the mines. The work involved the survey of four shafts and five levels, and owing to the steep pitch of the formation (66 degrees), and the fact that two of the shafts are vertical for some distance from the surface, afterwards changing to the dip of the formation, presented as difficult conditions for surveying as occur in the Upper Peninsula.

After completing the survey of these mines, the class was taken to the Norrie Mine, where the succeeding two weeks were spent. This large and celebrated mine furnished a splendid field for the study of the operations necessary in mining large bodies of soft ore. The fifth week was spent in visiting other prominent mines of the Gogebic Range.

Three days were spent at the Colby Mine, and one day each at the Newport and Brotherton Mines.

The sixth and last week was spent about Ishpeming at the following mines: Lake Angeline, Lake Mine of the Cleveland Company, Lake Superior, and the Queen and Buffalo Mines. The officers of all the mines visited took great pains to give us every assistance possible, and answered the many questions of the students with accuracy and courtesy.

(*b*). *Hydraulics.*

Merriman's "Hydraulics" was used as a text book, and was closely followed, reference to special parts of other books and to technical papers being made as found necessary. During the past year the Pelton Water Wheel Company donated a twenty-four-inch wheel to the School. It is hoped that in the near future other hydraulic motors and apparatus may be collected, and a small hydraulic laboratory started.

Plane Surveying.

The class numbered twenty-seven at the beginning of the course in the winter term, but was reduced to twenty-two when the field work of the summer term began. Davies' "Surveying" was used as a text book during the winter term, and Johnson's "Surveying" during the summer term.

It has been decided to discontinue the use of Davies' book in the future, and to adopt Johnson's book for the entire course.

The surveys as tabulated in the catalogue were carried out, with the exception of a subdivision of a section.

The triangulation survey was made at the Atlantic Mine Location for the purpose of making a topographical map of the property.

The railroad practice was had in running a line from the Huron Mine to the Atlantic Mine. In every possible way the field work was conducted as it would be in regular professional work.

(*d*). *Topographical Drawing.*

Instruction in this subject was given in connection with the surveying of the winter term, and eight hours per week for eight weeks were occupied in the Drawing Room.

The needs of the department for the coming year will be chiefly in the line of assistance in the work of the spring and summer terms. It has been found by experience, that not more than eighteen or twenty students can be taken to any one mine for a prolonged visit. More than this number cause a serious inconvenience to the mine officials, and it is not policy for the School in any way to make its students obnoxious to the mine people.

The only remedy is to divide the classes, when composed of more than twenty students, into two parties, each party going to a different mine to do its work.

As the next class in mining will number about thirty-five, this division into two parties will be required next spring.

An assistant is necessitated by any such arrangement. Such an assistant would cost the School about one hundred dollars and traveling expenses.

The field work in plane surveying will also necessitate additional help. In order properly to check the work of the students both in the field and office, and to make the work as practical as possible, a corps of three is necessary. Two assistants can be secured for this work for from one hundred and twenty-five to one hundred and fifty dollars each, or three hundred dollars in all. The operating expenses for the summer school in surveying are estimated to amount to about one hundred dollars.

Estimates.

Instruments—an Eidograph for the surveying outfit..........	$75 00
Assistant for the spring work at the mines....................	100 00
Expenses of above assistant....................................	70 00
Expenses of professor in charge................................	70 00
Two assistants for summer work in surveying................	300 00
Expenses of summer school in surveying.....................	100 00
Total..	$715 00

F. W. DENTON.

§ 14.

M. E. WADSWORTH,

Director of the Michigan Mining School:

DEAR SIR: I beg leave to submit the following report on the course of study placed in my charge during the current year:

(*a*). *Petrography.*

Last autumn, as we stated on page 32 of the catalogue, this course was omitted, the class which should have taken it not being prepared. This autumn the course is given six hours a week to a class of the second year men, the enrollment having been twenty-five. They have made good progress — better than heretofore. This number is larger than with closest crowding can find working light in the laboratory, and some must find places in the mineralogical room. As yet these are but few, but with two or three more the continuous presence of an instructor in each room will be necessary. The present class keep the instructors very busy during laboratory hours, and some time before and after. The question of working room will soon be a serious one. The most obvious plan is to divide the classes into sections, but this would require more hours of instruction. Some inexpensive assistance might be given by one who would relieve the instructors in the distribution and care of microscopic material.

In regard to microscopes and other apparatus. we are much better placed than heretofore. Of the former we have enough for the present, and probably for two years to come. The plan of having a microscope for each student, who is responsible for it, results in but little deterioration, to be paid for by the State. During the year an improved section cutting-machine has been added, and a few thin sections of typical well studied foreign rocks from Sweden and Norway, which have proved very useful. The new cabinet for thin sections has arrived and all the School collections have been placed in them systematically, but some of the older ones fit rather too loosely. At trifling cost they can be adjusted.

Of certain important rocks, minerals and structures, we have as yet barely one or two thin sections. Under such circumstances it is difficult to plan that each one of a large class shall see all that he ought. Steady addition should therefore be made to the cabinet of mineral sections, not in accumulating mere duplicates, but in obtaining sections from new rocks which will repeat certain important features, but under new attendant circumstances.

With increasing classes it will be more and more necessary to use the projection microscope for demonstration. No diagrams can illustrate so well the translucent forms and colors of thin sections, and in no other way can we show to all at once, and exactly point out what is to be observed. The addition of Cohen's portfolio of large microphotographs would be very desirable as a help in illustrating before large classes. I hope to pick this up second hand. The Physical Department already has a projection apparatus and an electric lamp.

Until we have some source of electric current which may be drawn on at any time, however, this plant is useless; so that, unless storage batteries are put in as planned by the Electrical Department, which I would strongly urge, we must have an oxygen light with its initial cost, cost of running, risk of explosion, etc.

The same general method of teaching has been employed this fall as before, viz., printed tables, hektographed syllabi and lectures, although the lectures have been thoroughly rewritten.

We have met one difficulty, the same as we shall see we have encountered in stratigraphy. We have already exhausted the market of Levy's "Tableau des Birefringences."

I estimate the expenses for the Petrographical laboratory according to the items above, to be for the next two years, as follows:

Thirty cameræ lucidæ at $1.50	$45 00
One Bertrand reflectometer	70 00
Oxygen light outfit	75 00
Cost of running the same two years	50 00
Cohen's Portfolio of Photographs	40 00
Repairs on microscopes and apparatus	10 00
Thin sections	100 00
Total	$390 00

(*b*). *Economic Geology.*

In the winter term of 1891–1892, I studied Phillips's "Ore Deposits" with a class of five third year men and special students, supplementing the book with a few lectures, meeting five hours a week. We read the general part carefully, and select points of the detailed descriptions. The book is rather too old and not well adapted for a text-book.

(*c*). *Paleontology and Stratigraphical Geology.*

This is given this fall to a class of thirteen third year men, and four hours a week only have been allotted to it. It was found that the text-book heretofore used, Geikie's "Geology,' was exhausted. We have, therefore, been compelled to change to Leconte's "Elements of Geology." The policy of the School seems to have been to use, in every case, the very best book on the subject obtainable, rather than one of the ordinary text-books, and to cut out whatever of minor importance could not be crowded into the course. This has the great advantage that students thus accumulate a library of standard reference books of permanent value, but it seems also true that the editions of books of this stamp are not large and are easily exhausted, nor are many kept in stock except at the publishers. Would it not be advisable for the School formally to notify the publishers a year or more in advance of its requirements?

The supplementary instruction by lectures and laboratory work on the students' fossil collection remains as before. We have had some additions to our collection by gift and exchange but not enough to make good the legitimate wear and tear of handling. Moreover, important finds of fossils in the west, in Texas and elsewhere, have brought on the market, at reasonable prices, fossils to illustrate points where we are weak. We have almost nothing to represent the vertebrates, and while we lack the space for skeletons or larger bones, a small collection of the various kinds of teeth would, I think, be useful.

The charts of fossils have been arranged to roll up like window curtains, a much more convenient arrangement than before. Some important additions have also been made to the library.

I estimate that the wear on the students' collection for the next two years can be made good and the additions recommended obtained for one hundred dollars.

Respectfully submitted,

(Signed). ALFRED C. LANE.

§ 16.

DR. M. E. WADSWORTH,
Director of the Michigan Mining School.

DEAR SIR—I have the honor to submit to you herewith a report on the condition of the Library of the Michigan Mining School.

Respectfully,
(Signed) ROBERT IRWIN REES.

The Library of the Mining School now has eight thousand and ninety-five volumes, an increase of three hundred and ninety-seven during the year. The purchases this year have been made in the endeavor to supply the Library, as far as our limited funds would permit, with the latest publications on scientific and technical subjects so that the student may have the benefit of the latest and most approved methods of scientific investigation which relate to the courses which he is pursuing here. There has been a considerable increase in the number of periodicals received in the Reading Room, the number now reaching one hundred and fifty-four, an increase over last year of twenty-eight. The periodicals sent as gifts to the Library have become quite numerous, as many again as we had last year, and I embrace this opportunity to extend through you a grateful acknowledgment to the publishers for their generous contributions. It is unnecessary to mention the fact that this is an age of periodical publications and that the results of hard study and original research are first brought before the world through the medium of journals and transactions. It is very evident therefore what an important factor in an institution of this character is a well chosen collection of technical journals, transactions and other scientific periodicals.

The issue of books from the Library has steadily increased, and its value as an adjunct to their professional studies is becoming more and more apparent to the students. It has previously been pointed out how indispensable is the Library to every instructor in the institution.

The requirements of the Library are still very great and there is not one department which does not need further development. The most imperative need at present, however, is for more room. The Reading Room is not more than a third large enough to accommodate the number of students now enrolled, and with a further increase it will be, of course, much worse. It is impossible to make a proper classification of the books in the Library on account of the lack of room. There is absolutely no space remaining for the larger sized volumes, quartos and folios, and the files of newspapers have to be stored in the attic, which renders it so difficult to consult them, that they are rendered almost valueless. There will shortly be sent to the binder a year's accumulation of periodicals, and it is still an unsolved question in my mind as to what shall be done with the larger volumes when they are returned.

If an appropriation is granted by the present Legislature for a new building which is so greatly needed, the Library can then be moved into the present drawing room where it can have the space for expansion and development which it so greatly needs, and the desired room for the Reading Room can be furnished by the adjoining office and lecture room.

REPORT OF THE BOARD OF VISITORS.

HON. FERRIS S. FITCH,
Supt. Public Instruction:

DEAR SIR.—The committee appointed by you to act as a Board of Visitors to the Michigan Mining School respectfully report as follows:

Finding it impossible to arrange a date which would enable the entire committee to make the inspection at the same time, two of us visited the institution on Wednesday and Thursday, March 30 and 31, and the third on April 8 and 9. We were cordially received, and every effort was made to place us in possession of the items asked for and appertaining to the duties assigned us. The examination was as careful and searching as time would permit.

The first visit was made during the progress of the regular work, and the second during examination week at the close of the term. Thus the opportunity was afforded the committee of witnessing the work of students in the class-room and laboratories, as well as the results of the work as exhibited by the examinations. So far as we are able to judge, the work of the institution is being pushed along its legitimate lines and solidly and conscientiously performed both by students and instructors. The lectures indicated carefulness of preparation and thorough understanding of the subjects taught on the part of the instructors, and the character of the examinations showed that there was no disposition to accept less from the students. We were favorably impressed with the earnestness of purpose which seemed to pervade the students as a body, and with a manifest fitness of the members of the faculty for their special lines of work. Some of these men, we understand, left much more lucrative positions on account of their love for their specialty, and their desire to devote themselves exclusively to it. Such men cannot fail to do strong work. It was with regret that we learned, soon after our visit, of the resignation of Dr. Keller. He is unquestionably one of the ablest men in the institution. The building, rooms, laboratories, apparatus, and machinery all indicate efficiency on the part of those having them in charge. The Mining School is purely and distinctly a professional school, having for its object the practical training of its students in Mining Engineering, and we believe it is carrying out the purpose for which it was established. Of course much of the theoretical is taught, but so far as your committee could learn, it is with sole reference to its practical bearing upon what is to follow.

Although much time is spent upon theoretical mathematics, the object is to give to the student a mastery of those principles which will be necessary in his after-work of surveying and engineering. The students are then taken to the field and into the mines, and under the guidance and direction of an expert (Prof. Denton), are taught the practical applications of the principles learned, and other necessary operations of mining. The same methods prevail in the other departments of the School. It is this element of practicability in all the work of the School, in our opinion, which has brought to the School the very general support of the people of the Upper Peninsula and of mining men in particular. The consensus of opinion among all classes is that the School has a direct and financial value to the State. It promotes intelligence in methods of mining, develops inventiveness in the line of mining machinery and directs thought to measures for securing greater safety to miners.

Your committee, or at least one member of it, before visiting the School, had always regarded it as an expensive one, considering the number of students enrolled. But after careful investigation at the School, and an examination into the methods pursued by the Board of Control, there can be no doubt but that all means appropriated have been economically and intelligently expended. Of course it is well understood by all that technical education is necessarily much more expensive than general education, on account of the peculiar character of the work. The equipment, including buildings, laboratories, apparatus, machinery and collections in geology, is very costly. A comparison of the per capita cost at the Michigan Mining School, however, with the cost at other similar institutions, shows that the Michigan School is the cheapest. This cost will decrease as the number of students increases. The Faculty, as at present constituted, could undoubtedly handle a larger number of students than are now enrolled in the School (seventy-six), and yet the work of the various departments could not be satisfactorily performed with a less number of instructors. In fact, were it not for the union of the School and the Geological Survey, the Faculty would have to be increased; but this arrangement adds to the teaching force for a large part of the year, three skilled assistants, Drs. Lane and Patton, and Prof. Seaman.

This brings us to the consideration of the question of the union of the Mining School and the Geological Survey. We believe this arrangement to be mutually advantageous, and a direct saving to the State. It places at the head of the Survey, as State Geologist, the Director of the School, Dr. Wadsworth, who is eminently qualified both as to scholarship and executive ability, for the position he holds, and strengthens the Faculty of the School by adding to the teaching force the three capable members of the Survey. With the means at the command of the Geological Board, it would be impossible to retain the services of these men; but by dividing their time between the School and the Survey, and receiving a part of their salary from the School and part from the Survey, the State is enabled to retain them in its employ. It also furnishes convenient headquarters for the Survey, and places at the service of the School its valuable geological collections. At no other place in the State could this collection be so well preserved and made of such practical value. The wisdom of locating the School where it is is apparent to all who have ever visited this region. It is surrounded by some of the richest copper and iron mines in the world, and the student has the opportunity of making constant practical application of his studies. Some means, however, should be adopted at once to reduce the expense of living to the students. We understand that it is very difficult for the students to find rooms and board without paying exorbitant prices therefor. If means could be devised for relieving this condition of things it would be well; in fact, it is almost imperative that something be done in this direction. There ought to be a room at the building, also, large enough for an assembly room. There are many occasions when it is quite important to bring the students together in a body. We believe, also, that the heating apparatus should be removed from the main building and placed in a building by itself.

The Michigan Mining School, we may say in closing, has come to stay, because it has demonstrated its fitness to live. Whatever may have been its weakness in the past it is now doing valuable work. It is well equipped, has an able Faculty, and a demand greater upon it than it can now supply. We see no reason why it should not be a very valuable auxiliary in the future development of the mining resources of the State.

Respectfully yours,

(Signed) D. A. HAMMOND,
PERRY F. POWERS,
S. E. WHITNEY,
} *Committee.*